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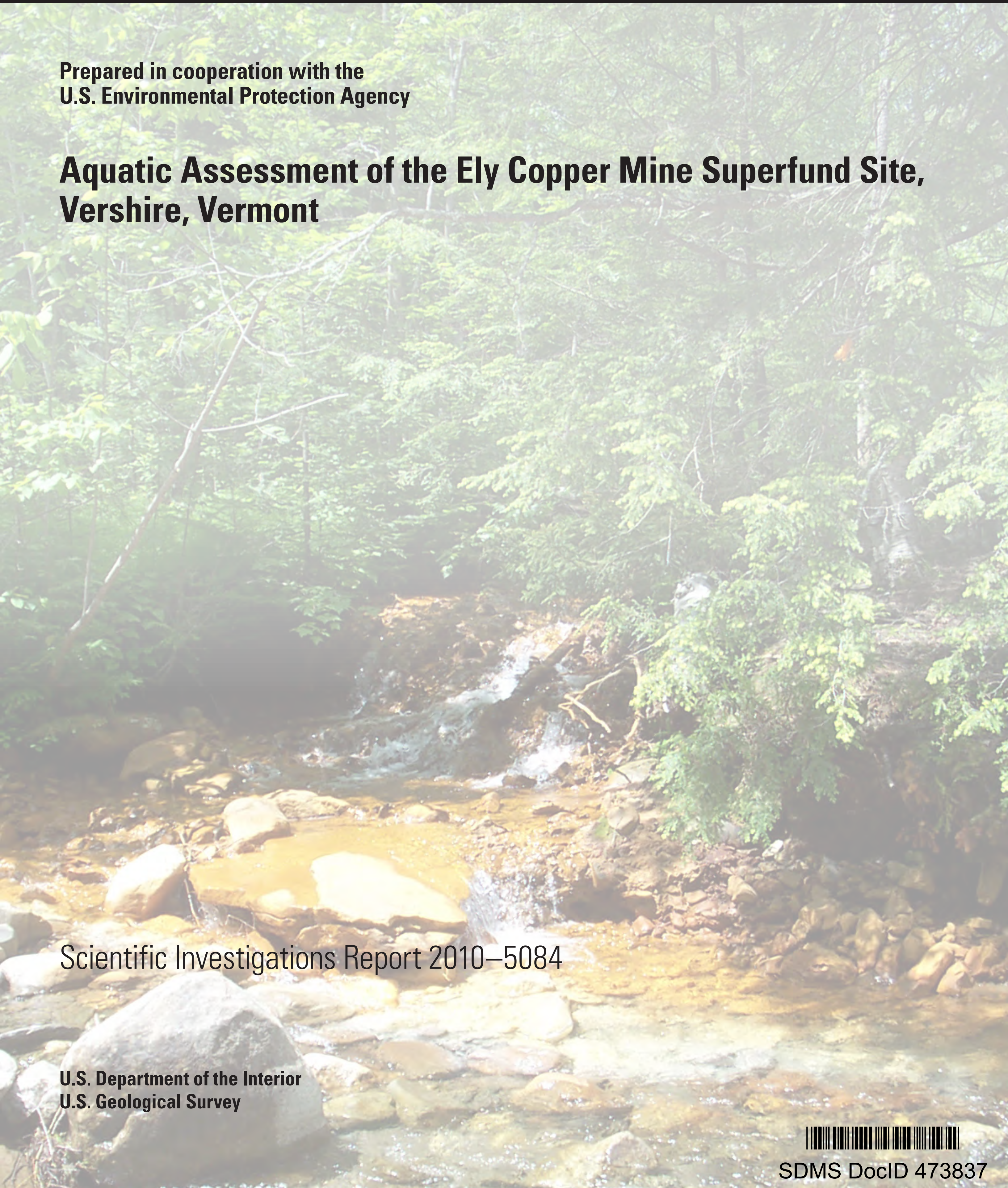

Prepared in cooperation with the
U.S. Environmental Protection Agency

Aquatic Assessment of the Ely Copper Mine Superfund Site, Vershire, Vermont

Scientific Investigations Report 2010–5084

U.S. Department of the Interior
U.S. Geological Survey

Cover photograph. The confluence of Ely Brook, flowing from the back to the front of the scene, with Schoolhouse Brook, flowing from left to right.

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By Robert R. Seal, II, Richard G. Kiah, Nadine M. Piatak, John M. Besser, James F. Coles, Jane M. Hammarstrom, Denise M. Argue, Denise M. Levitan, Jeffrey R. Deacon, and Christopher G. Ingersoll

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U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2010

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Conversion Factors

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
square kilometer (km^2)	247.1	acre
square centimeter (cm^2)	0.001076	square foot (ft^2)
square meter (m^2)	10.76	square foot (ft^2)
square centimeter (cm^2)	0.1550	square inch (ft^2)
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic meter (m^3)	6.290	barrel (petroleum, 1 barrel = 42 gal)
liter (L)	33.82	ounce, fluid (fl. oz)
liter (L)	2.113	pint (pt)
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)
cubic meter (m^3)	264.2	gallon (gal)
cubic meter (m^3)	0.0002642	million gallons (Mgal)
liter (L)	61.02	cubic inch (in^3)
cubic meter (m^3)	35.31	cubic foot (ft^3)
cubic meter (m^3)	1.308	cubic yard (yd^3)
cubic meter (m^3)	0.0008107	acre-foot (acre-ft)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\times°C)+32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1927 (NAVD 27).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (μg/L).

Acronyms Used in this Report

AFDW	ash-free dry weight
ALU	aquatic-life use
ANOVA	analysis of variance
ANR	Agency of Natural Resources (Vermont)
AVS	acid volatile sulfide
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	ambient water-quality criteria
BERA	Baseline Ecological Risk Assessment
BLM	Biotic Ligand Model
CBR	critical body residue
CCC	criterion continuous concentration
CERC	Columbia Environmental Research Center (USGS)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMC	criterion maximum concentration
CRREL	Cold Regions Research and Engineering Laboratory (U.S. Army Corps of Engineers)
CVAF	cold-vapor atomic fluorescence
CWIBI	coldwater index of biotic integrity
DGPS	differential global positioning system
DOC	dissolved organic carbon
DTH	depositional-targeted habitat

ESB	equilibrium-partitioning sediment benchmark
HI	hazard index
HQ	hazard quotient
IBI	index of biotic integrity
ICP-AES	inductively coupled plasma–atomic emission spectroscopy
ICP-MS	inductively coupled plasma–mass spectrometry
MWIBI	mixed water index of biotic integrity
PEC	probable effects concentration
PEQ	probable effects quotient
QMH	qualitative multi-habitat
ROS	regression on order statistics
RPD	relative percent difference
RTH	riffle-targeted habitat
SEM	simultaneously extractable metals
SEM-AVS	simultaneously extractable metals–acid volatile sulfide
TOC	total organic carbon
TU	toxic units
USACE	U.S. Army Corps of Engineers
USBM	U.S. Bureau of Mines
USGS	U.S. Geological Survey
VTAWQC	Vermont ambient water-quality criteria
VTDEC	Vermont Department of Environmental Conservation
VTNRB	Vermont Natural Resources Board
WAAS	Wide Area Augmentation System

Element Symbols Used in this Report

Ag	silver
Al	aluminum
As	arsenic
B	boron
Ba	barium
Be	beryllium
Bi	bismuth
Ca	calcium
Cd	cadmium
Ce	cerium
Cl	chlorine
Co	cobalt
Cr	chromium
Cs	cesium
Cu	copper
Dy	dysprosium
Er	erbium
Eu	europium
F	fluorine
Fe	iron
Ga	gallium
Gd	gadolinium
Ge	germanium
Ho	holmium
Hg	mercury
K	potassium
La	lanthanum
Li	lithium
Lu	lutetium
Mg	magnesium
Mn	manganese
Mo	molybdenum
Na	sodium
Nb	niobium
Nd	neodymium
Ni	nickel
P	phosphorus
Pb	lead
Pr	praseodymium
Rb	rubidium
Sb	antimony
Sc	scandium
Se	selenium
Sm	samarium
Sr	strontium
Ta	tantalum
Tb	terbium
Th	thorium
Ti	titanium
Tl	thallium
Tm	thulium
U	uranium
V	vanadium
W	tungsten
Y	yttrium
Yb	ytterbium
Zn	zinc
Zr	zirconium

Aquatic Assessment of the Ely Copper Mine Superfund Site, Vershire, Vermont

By Robert R. Seal, II, Richard G. Kiah, Nadine M. Piatak, John M. Besser, James F. Coles, Jane M. Hammarstrom, Denise M. Argue, Denise M. Levitan, Jeffrey R. Deacon, and Christopher G. Ingersoll

Abstract

The Ely Mine, which operated from 1821 to 1905, and its area of downstream impact constitute the Ely Copper Mine Superfund site. The site was placed on the National Priorities List in 2001. The mine comprises underground workings, foundations from historical structures, several waste-rock piles, roast beds associated with the smelting operation, and slag piles resulting from the smelting. The mine site is drained by Ely Brook, which includes several tributaries, one of which drains a series of six ponds. Ely Brook empties into Schoolhouse Brook, which flows 3.3 kilometers and joins the Ompompanoosuc River.

The aquatic ecosystem at the site was assessed using a variety of approaches that investigated surface-water quality, sediment quality, and various ecological indicators of stream-ecosystem health. The degradation of surface-water quality is dominated by copper with localized effects caused by iron, aluminum, cadmium, and zinc. Chronic water-quality criteria for copper are exceeded in the surface water of four of the six ponds on the Ely Brook tributary, and all of Ely Brook and Schoolhouse Brook, and of the Ompompanoosuc River downstream of the confluence with Schoolhouse Brook. Comparison of hardness-based and Biotic Ligand Model–based water-quality criteria for copper yields similar results with respect to extent of impairment. However, the Biotic Ligand Model criteria are mostly lower than the hardness-based criteria and thus suggest a greater degree of impairment, particularly in the Ely Brook watershed, where dissolved organic carbon concentrations and pH values are lower. Surface-water toxicity testing correlates strongly with the extent of impact. Likewise, riffle-habitat benthic invertebrate richness and abundance data support these results through the stream environment. Similarly, the index of biotic integrity for the fish community in Schoolhouse Brook and the Ompompanoosuc River document degraded habitats throughout Schoolhouse Brook from Ely Brook down to the Ompompanoosuc River.

The sediment environment shows similar extents of impairment also dominated by copper, although localized degradation due to chromium, nickel, lead, and zinc was documented on the basis of probable effects concentrations. In contrast, equilibrium-partitioning sediment benchmarks indicate no toxic effects would be expected in sediments at the reference sites, and uncertain toxic effects throughout Ely Brook and Schoolhouse Brook, except for the reference sites and site EB-600M. The results for site EB-600M indicate predicted toxic effects. Acute toxicity testing of in situ pore waters using *Hyalella azteca* indicates severe impacts in Ely Brook reaching 100 percent lethality at site EB-90M. Acute toxicity testing of in situ pore waters using *Chironomus dilutus* shows similar, but not as severe, toxicity. Neither set of in situ pore-water toxicity tests showed significant impairment in Schoolhouse Brook or the Ompompanoosuc River. Chronic sediment toxicity testing using *Hyalella azteca* indicated significant toxicity in Ely Brook, except at site EB-90M, and in Schoolhouse Brook. The low toxicity of EB-90M may be a reflection of the low lability of copper in that sediment as indicated by a low proportion of extractable copper (1.1 percent). Depositional-targeted habitat invertebrate richness and abundance data support these conclusions for the entire watershed, as do the index of biotic integrity data from the fish community.

The information was used to develop an overall assessment of the impact on the aquatic system that appears to be a result of the acid rock drainage at the Ely Mine. More than 700 meters of Ely Brook, including two of the six ponds, were found to be severely impacted, on the basis of water-quality data and biological assessments. The reference location was of good quality based on the water quality and biological assessment. More than 3,125 meters of Schoolhouse Brook are also severely impacted, on the basis of water-quality data and biological assessments. The biological community begins to recover near the confluence with the Ompompanoosuc River. The evidence is less conclusive regarding the Ompompanoosuc River. The sediment data suggest that the sediments could be a source of toxicity in Ely Brook and Schoolhouse Brook. The surface-water assessment is consistent with the outcome of a surface-water toxicity testing program performed by the U.S. Environmental Protection Agency for Ely Brook and Schoolhouse Brook and a surface-water toxicity testing program and in situ amphibian testing program for the ponds.

Introduction

This report presents an evaluation of the aquatic ecosystem associated with the Ely Copper Mine Superfund site in Vershire, Orange County, VT. The Ely Copper Mine Superfund site was placed on the U.S. Environmental Protection Agency (USEPA) National Priorities List in 2001. Results of detailed mine-waste investigations show that the mine, which operated intermittently from the early 1800s until 1905, is contributing metals and highly acidic waters to local streams (Hammarstrom and others, 2001a, b; Kierstead, 2001; Seal and others, 2001; Piatak and others, 2003, 2004; TechLaw, Inc., 2008; URS Corporation, 2009). Contaminated surface waters and sediment are transported from the mine site by Ely Brook. Ely Brook flows approximately 0.15 kilometer (km) from the lowermost mine-waste piles before entering Schoolhouse Brook, which then flows approximately 3.3 km before entering the Ompompanoosuc River (figs. 1 and 2). The area included in this report comprises the site of historical mining operations, downstream aquatic habitats, and adjacent upstream aquatic habitats selected to represent unimpacted reference conditions. Water bodies include Ely Brook, which drains most of the historical mine site, the tributaries to Ely Brook, including a series of ponds which drain into one of the tributaries, Schoolhouse Brook, which receives drainage from Ely Brook, and the Ompompanoosuc River, which is the receiving water body for Schoolhouse Brook.

Purpose and Scope

The goals of this report are to (1) characterize water and sediment quality and biological communities for water bodies in the Ely Mine study area, (2) compare and contrast surface-water, pore-water, and sediment trace-element concentrations, (3) relate trace-element concentrations to aquatic invertebrate and fish assemblages, and (4) evaluate the toxicity of surface water, pore water, and sediment. Results from this study will contribute to an understanding of the relations among the chemical, physical, and biological components of waterways that are affected by acid-mine drainage. Information from these results will be used in the development of a remedial investigation and feasibility study plan for the site, which will meet the broad U.S. Geological Survey (USGS) goal of furnishing data needed by other Federal agencies for management and remediation of contaminated sites, and will provide valuable information for the characterization of the impact of acid-mine drainage on the ecological condition of water bodies downstream of the Ely Mine site. Ultimately, this information will be used in making decisions for remedial actions necessary to mitigate future contamination from the mine and for developing a longer term monitoring program to assess the effectiveness of remediation. This report has been prepared, in part, to support the Ely Copper Mine Aquatic Baseline Ecological Risk Assessment (BERA; TechLaw, Inc., 2008) being conducted under the regulatory framework of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). These two reports will complement a source-area remedial investigation being conducted by USEPA and its contractors (URS Corporation, 2009).

Supporting streamflow and water-quality data collected in August and September 2006 are stored in the USGS National Water Information System (*http://nwis.waterdata.usgs.gov/nwis*). Water-quality, stream sediment, fish-tissue, and fish and benthic macroinvertebrate assemblage data collected from 2000 to 2007 are published in Argue and others (2008).

Report Organization

The report assesses the environmental conditions of the aquatic ecosystem associated with the abandoned Ely Mine site, describes the approach and methods selected to document these conditions, describes the physical characteristics of the site, documents the nature and extent of contamination, integrates this information to form a conceptual model of the site with respect to the transport and fate of contaminants, and summarizes these results in terms of risks posed to both the aquatic ecosystem and human health.

This introductory section provides background of the site including summaries of the mining history and ownership, and previous and concurrent activities at the site. The second section describes the approach used to identify sites for detailed study, and the methods employed to investigate surface water, sediment pore water, sediment, and biota characteristics, and toxicity testing. The third section describes the physical setting of the site including the historical mining landscape, geomorphology and surface-water hydrology of the watershed, depositional sites within the streams, and biologic and ecologic features. The next section documents the nature and extent of contamination in Ely and Schoolhouse Brooks, and in the Ompompanoosuc River in surface water, pore water, and sediments in terms of water-quality parameters, concentrations of metals, other inorganic constituents, organic constituents, and contaminant loads for comparison with biologic indicators of aquatic ecosystem health. The Discussion integrates the results of the previous sections to produce an integrated model describing the transport and fate of contaminants away from source areas. Implications of the aquatic ecosystem remedial investigation to a baseline ecological assessment of the site are discussed. The last section is a brief summary of the conclusions of the study.

Site Background

The Ely Copper Mine Superfund site is located in a rural area on Beanville Road, Vershire, Orange County, VT, in the watershed of Schoolhouse Brook—a tributary of the Ompompanooosuc River; the West Branch of the Ompompanoosuc River includes the Elizabeth Mine Superfund site, south of the Ely site (fig. 1). The site encompasses approximately 730 hectares (ha), of which 110 to 140 ha were used for

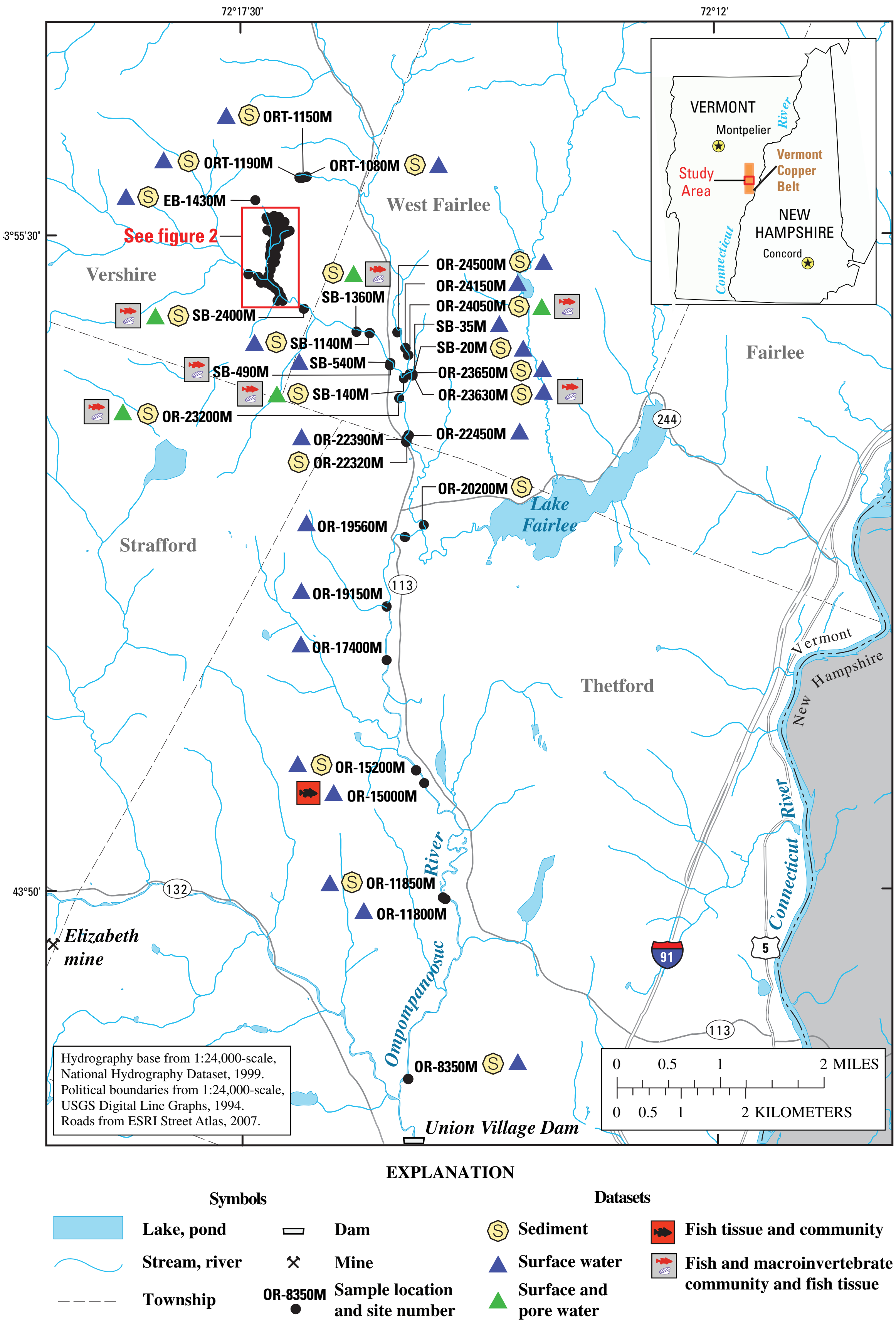


Figure 1. Sampling location numbers and identifiers for data collected in the Ompompanoosuc River and Schoolhouse Brook, Vershire, VT. Also shown are the locations of the Elizabeth Mine Superfund site, and the Union Village Dam just below the confluence of the West Branch of the Ompompanoosuc River with the Ompompanoosuc River.

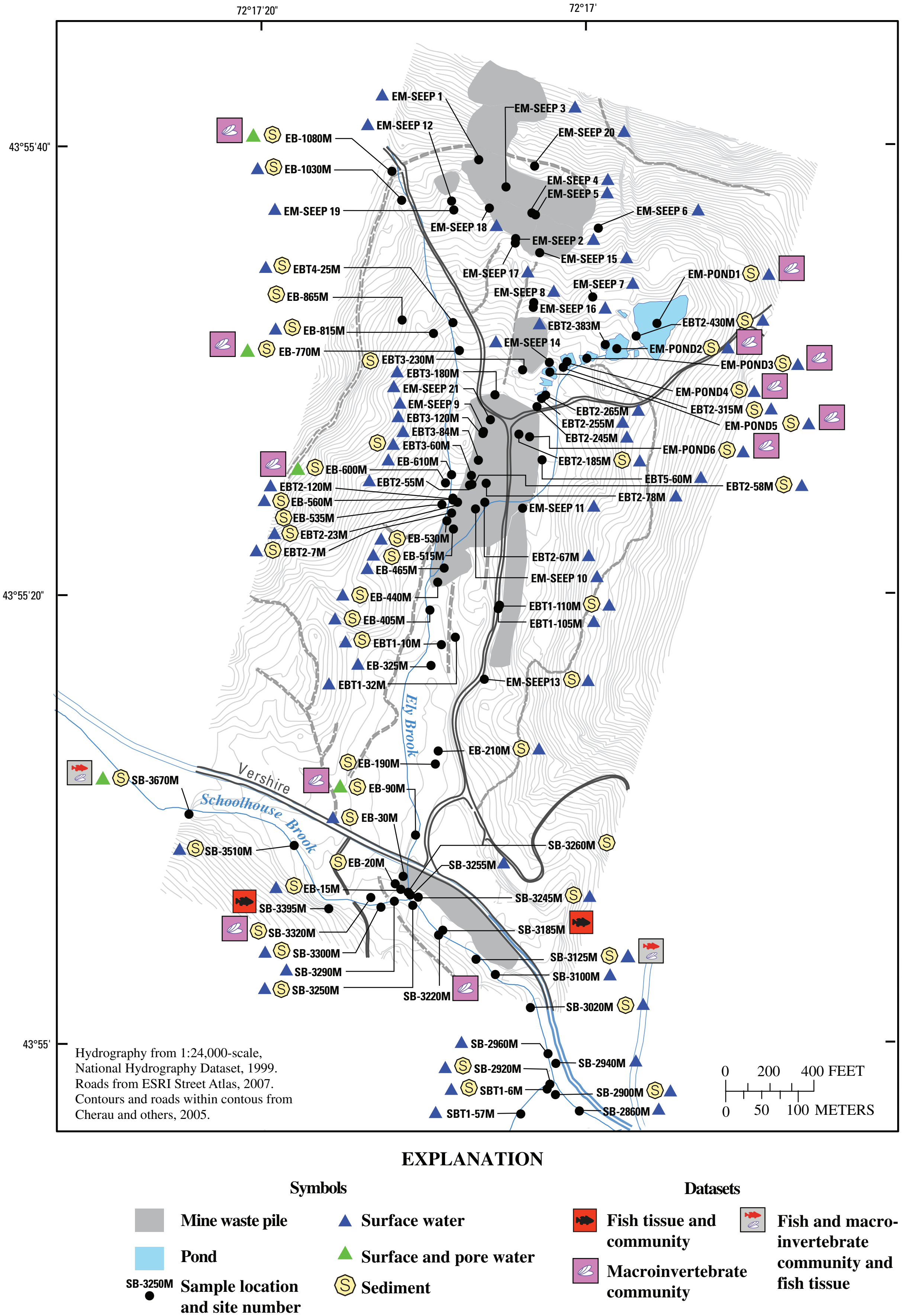


Figure 2. Sampling location numbers and identifiers for data collected at the Ely Mine Superfund site, Vershire, VT.

mining activities between 1821 and 1920 with peak production in the 1870s and 1880s (Kierstead, 2001). Mining ceased in 1905, but during World War I, a flotation mill constructed onsite processed material from ore dumps. The property is currently owned by Ely Mine Forest, Inc., and Green Crow Corporation.

The site extends up the Ely Brook watershed to the crest of the ridge (fig. 2). Near the top of the ridge, a series of adits and inclined shafts accessed the ore body in a northeasterly direction. Extending downslope from the main shaft is a series of waste-rock piles and a small area of flotation tailings, followed by roast beds and finally the smelter site, including a large slag pile on the banks of Schoolhouse Brook. Two main tributaries combine to form Ely Brook. One tributary flows in a southerly direction from the area west of the mine workings; the other flows in a southwesterly direction through a series of ponds east of the mine workings. Both main tributaries converge in the lower waste piles to form the main channel of Ely Brook.

The Ely Mine site has been the subject of numerous geological and environmental studies, some of which predated the remedial investigation initiated by USEPA in 2000. Early summaries of the geology and mining history of the Ely Mine are provided by Wheeler (1883), Smyth and Smith (1904), Weed (1911), Buerger (1935), White and Eric (1944), Hermance and others (1949), and Abbott (1973). More recently, the geology of the Ely Mine has been described by Slack and others (1993; 2001) and Offield and others (1993), and the mining history has been discussed by Kierstead (2001) and Cherau and others (2005).

Environmental investigations at the site prior to placement on the National Priorities list include studies by the Vermont Agency of Natural Resources (ANR), the U.S. Bureau of Mines (USBM), and the USGS. The Vermont ANR evaluated the fish community around the site in 1988. The USBM conducted bench-scale pilot tests of passive treatment of acid-mine drainage at the site (McSurdy and others, 1995). The USGS presented preliminary results of investigations of mine-waste and mine-drainage characteristics (Hammarstrom and others, 2001a, b; Seal and others, 2001). They also investigated the environmental mineralogy and geochemistry of slag from the site (Piatak and others, 2003, 2004).

The remedial investigation, to date, has included a number of studies on the environmental characteristics and mining history of the site. At the request of the USEPA, the U.S. Army Corps of Engineers (USACE) and the USGS collaborated on a study on spring runoff in 2002 (Holmes and others, 2002). The USGS investigated the geochemical characteristics of mine waste at the Ely Mine (Piatak and others, 2004). In the course of the remedial investigations, the USEPA and its contractors have conducted surface-water (2005, 2006) and sediment (2000–2001, 2004, 2006) sampling and bioassays (2006) of surface waters [Agency for Toxic Substances and Disease Registry (ATSDR), 2008; TechLaw, 2008; URS Corporation, 2009]. The mining history of the site has also been summarized by Cherau and others (2005) as part of the remedial investigation.

Study Approach and Methodology

This study included a physical characterization of the water bodies in the Ely Mine study area; a chemical analysis of surface water, pore water, and sediment; toxicity testing of surface waters, pore waters, and bulk sediments; and a biological analysis of aquatic macroinvertebrate and fish assemblages. The purpose of analyzing these various components in the study was to provide an ecological evaluation that was more comprehensive than one based on the traditional triad approach of sediment chemistry, toxicity testing, and infaunal community composition (Long and Chapman, 1985). The study included 12 stream (lotic) locations, each delineated with a 100-m sampling reach, and six pond (lentic) locations. Water samples were collected during August and September 2006. Surface-water samples were collected at the 12 stream locations: 4 on Ely Brook, 5 on Schoolhouse Brook, and 3 on the Ompompanoosuc River (figs. 1 and 2; table 1). Areas of sediment deposition were not found in 2 of the 12 stream locations, and therefore pore-water and sediment samples were collected at 10 stream locations: 4 on Ely Brook, 4 on Schoolhouse Brook, and 2 on the Ompompanoosuc River (figs. 1 and 2; table 1). During September 2006, benthic invertebrate assemblages were sampled, fish assemblages were surveyed, and fish tissue was collected for contaminant analysis. Within the stream reaches at 12 locations, macroinvertebrate assemblages were sampled in riffle habitats, and fish assemblages were surveyed and fish tissue collected along the reach; invertebrate assemblages in depositional habitats were sampled at 10 of these reaches (figs. 1 and 2; table 1). Surface-water and sediment samples were collected at six ponds along a tributary to Ely Brook in September 2006. During October 2006, invertebrate assemblages were also sampled in six hydraulically connected ponds located within the watershed of the mine (figs. 1 and 2; table 1).

Selection of Sample Locations

A qualitative geomorphologic characterization of stream segments in Ely Brook, Schoolhouse Brook, and the Ompompanoosuc River was conducted in June 2006 to assist in determining optimum stream sampling locations where the collection and analysis of surface water, pore water, sediment, macroinvertebrates, and fish would provide an understanding of the relative magnitude of contaminants at the site and their effects on aquatic biota. Based on the characterization, sampling locations were selected to provide a more holistic understanding of the differences in surface water, pore water, and sediment chemistry in a stream system affected by acid-rock drainage and the effects to aquatic biota. Where possible, samples were obtained in stream reaches that contained areas of deposition (pools) and areas of greater velocity (riffles).

Latitudes and longitudes for the geomorphologic characterization were determined with a 10-hertz (Hz) Trimble AgGPS 132 receiver and integrated with ESRI ArcMap

Table 1. Select characteristics for sampling locations at the Ely Mine study area, Vershire, VT.

[URS, URS Corporation; CRREL, U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory; ADL, Arthur D. Little, Incorporated; EPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; latitude and longitude are given in decimal degrees; SW, surface water; Sed, sediment; PW, pore water; B, benthic invertebrate; F, fish; Tox, toxicity test]

Site number	Stream	River meter[a]	Latitude	Longitude	Datasets	Historical name	Sampling organization
EB-15M	Ely Brook	15	43.91857	–72.28655	SW, Sed	EB-6, ELYM-8-SS, EB-PPT	CRREL, USGS
EB-20M	Ely Brook	20	43.91864	–72.28664	Sed	06Ely11	USGS
EB-30M	Ely Brook	30	43.91873	–72.28651	SW, Sed	SW-09, SED-09	URS
EB-90M	Ely Brook	90	43.91924	–72.28629	SW, PW, Sed, B, Tox	Site 4, 06Ely04, EB7, EMTT-3, LOC-49	USGS, EPA, ADL
EB-190M	Ely Brook	190	43.92012	–72.28595	Sed	SED5	EPA
EB-210M	Ely Brook	210	43.92028	–72.28590	SW, Sed	SW-10, SED-10	URS
EB-325M	Ely Brook	325	43.92134	–72.28601	SW	SW-39	URS
	Ely Brook	350	Confluence with Ely Brook Tributary 1				
EB-405M	Ely Brook	405	43.92203	–72.28604	SW, Sed	SW-33, SED-33	URS
EB-440M	Ely Brook	440	43.92237	–72.28590	SW, Sed	LOC-59, SW-11 SED-11	ADL, URS
EB-465M	Ely Brook	465	43.92255	–72.28579	SW	EB-5	CRREL
EB-515M	Ely Brook	515	43.92303	–72.28563	SW	EB5, SED4	EPA
EB-530M	Ely Brook	530	43.92313	–72.28574	SW, Sed	SW-12, SED-12	URS
EB-535M	Ely Brook	535	43.92333	–72.28583	Sed	ELY-EB-SS	USGS
	Ely Brook	540	Confluence with Ely Brook Tributary 2				
EB-560M	Ely Brook	560	43.92339	–72.28564	SW, Sed	SW-13, SED-13	URS
EB-600M	Ely Brook	600	43.92360	–72.28576	SW, PW, Sed, B	Site 3, 06Ely03	USGS
EB-610M	Ely Brook	610	43.92370	–72.28566	SW	LOC-57	ADL
EB-770M	Ely Brook	770	43.92524	–72.28552	SW, PW, Sed, B	Site 2, 06Ely02, SW-40	USGS, URS
	Ely Brook	800	Confluence with Ely Brook Tributary 4				
EB-815M	Ely Brook	815	43.92545	–72.28596	SW, Sed	SW-17, SED-17	URS
EB-865M	Ely Brook	865	43.92562	–72.28650	Sed	SED3	EPA
EB-1030M	Ely Brook	1,030	43.92710	–72.28650	SW, Sed	SW-18, SED-18	URS
EB-1080M	Ely Brook	1,080	43.92746	–72.28667	SW, PW, Sed, B	EB-1, Site 1, 06Ely01, SED1	CRREL, USGS, EPA
EB-1430M	Ely Brook	1,430	43.92984	–72.28875	SW, Sed	SW-20, SED-20	URS
EBT1-10M	Ely Brook Trib 1	10	43.92160	–72.28584	SW, Sed	SW-34, SED-34	URS
EBT1-32M	Ely Brook Trib 1	32	43.92169	–72.28560	SW	EB6	EPA
EBT1-105M	Ely Brook Trib 1	105	43.92204	–72.28487	SW	EB-7	CRREL
EBT1-110M	Ely Brook Trib 1	110	43.92208	–72.28484	SW, Sed	SW-36, SED-36	URS
EBT2-7M	Ely Brook Trib 2	7	43.92323	–72.28566	SW, Sed	SW-32, SED-32	URS
EBT2-23M	Ely Brook Trib 2	23	43.92336	–72.28556	SW, Sed	SW-31, SED-31	URS
	Ely Brook Trib 2	50	Confluence with Ely Brook Tributary 3				
EBT2-55M	Ely Brook Trib 2	55	43.92357	–72.28535	SW	EB3	EPA
EBT2-58M	Ely Brook Trib 2	58	43.92358	–72.28531	SW, Sed	SW-14, SED-14	URS
EBT2-67M	Ely Brook Trib 2	67	43.92336	–72.28509	SW	LOC-58	ADL
EBT2-78M	Ely Brook Trib 2	78	43.92359	–72.28507	SW	EB-3	CRREL
EBT2-120M	Ely Brook Trib 2	120	43.92341	–72.28564	SW	EB4	EPA
	Ely Brook Trib 2	125	Confluence with Ely Brook Tributary 5				

Table 1. Select characteristics for sampling locations at the Ely Mine study area, Vershire, VT.—Continued

[URS, URS Corporation; CRREL, U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory; ADL, Arthur D. Little, Incorporated; EPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; latitude and longitude are given in decimal degrees; SW, surface water; Sed, sediment; PW, pore water; B, benthic invertebrate; F, fish; Tox, toxicity test]

Site number	Stream	River meter[a]	Latitude	Longitude	Datasets	Historical name	Sampling organization
EBT2-185M	Ely Brook Trib 2	185	43.92420	–72.28450	SW,Sed	SW-37, SED-37	URS
EM-POND6	Pond	195	43.92417	–72.28432	SW, Sed, B, Tox	Pond 6, 06ElyPond6	USGS, EPA
EBT2-245M	Ely Brook Trib 2	245	43.92454	–72.28419	Tox	EMTT-2	EPA
EBT2-255M	Ely Brook Trib 2	255	43.92464	–72.28411	SW	SW-41	URS
EBT2-265M	Ely Brook Trib 2	265	43.92468	–72.28404	SW	EB-2	CRREL
EM-POND5	Pond	290	43.92497	–72.28397	SW, Sed, B, Tox	Pond 5, 06ElyPond5	USGS, EPA
EBT2-315M	Ely Brook Trib 2	315	43.92503	–72.28374	SW, Sed	SW-16, SED-16	URS
EM-POND4	Pond	320	43.92510	–72.28368	SW, Sed, B, Tox	Pond 4, 06ElyPond4, EMTT-1 REF	USGS, EPA
EM-POND3	Pond	345	43.92514	–72.28334	SW, Sed, B, Tox	Pond 3, 06ElyPond3	USGS, EPA
EBT2-383M	Ely Brook Trib 2	383	43.92531	–72.28302	SW	EB-2a	CRREL
EM-POND2	Pond	385	43.92526	–72.28282	SW, Sed, B, Tox	Pond 2, 06ElyPond2	USGS, EPA
EBT2-430M	Ely Brook Trib 2	430	43.92541	–72.28249	SW, Sed	SW-21, SED-21	URS
EM-POND1	Pond	432	43.92557	–72.28213	SW, Sed, B	Pond 1, 06ElyPond1	USGS
EBT3-60M	Ely Brook Trib 3	60	43.92369	–72.28532	SW, Sed	SW-30, SED-30	URS
EBT3-84M	Ely Brook Trib 3	84	43.92388	–72.28520	SW	EB-4	CRREL
EBT3-120M	Ely Brook Trib 3	120	43.92421	–72.28512	SW	EB2	EPA
EBT3-180M	Ely Brook Trib 3	180	43.92469	–72.28491	SW	EB1	EPA
EBT3-230M	Ely Brook Trib 3	230	43.92500	–72.28444	Sed	ELY-SS-2	USGS
EBT4-25M	Ely Brook Trib 4	25	43.92558	–72.28563	SW, Sed	SW-29, SED-29	URS
EBT5-60M	Ely Brook Trib 5	60	43.92388	–72.28411	SW	SW-51	URS
SB-20M	Schoolhouse Bk	20	43.90535	–72.25874	SW, Sed, Tox	SW-27, SED-27, EMTT-8	URS, EPA
SB-35M	Schoolhouse Bk	35	43.90549	–72.25894	SW	SB11	EPA
SB-140M	Schoolhouse Bk	140	43.90490	–72.26012	SW, PW, Sed, B, F, Tox	Site 5, 06Ely08, SED9	USGS, EPA
SB-490M	Schoolhouse Bk	490	43.90670	–72.26280	B, F	Ely Bk station 0.4, F-17	ADL
SB-540M	Schoolhouse Bk	540	43.90699	–72.26271	SW	SB-3	CRREL
SB-1140M	Schoolhouse Bk	1,140	43.91121	–72.26672	SW, Sed	LOC-52	ADL
SB-1360M	Schoolhouse Bk	1,360	43.91144	–72.26925	SW, PW, Sed, B, F, Tox	Site 4, 06Ely07, SW-01, SED-01	USGS, URS
SB-2400M	Schoolhouse Bk	2,400	43.91460	–72.27950	SW, PW, Sed, B, F, Tox	Site 3, 06Ely06, SED8	USGS, EPA
SB-2860M	Schoolhouse Bk	2,860	43.91582	–72.28350	Tox	EMTT-7	EPA
SB-2900M	Schoolhouse Bk	2,900	43.91602	–72.28391	SW, Sed	SW-02, SED-02	URS
	Schoolhouse Bk	2,915	Confluence with Schoolhouse Brook Tributary				
SB-2920M	Schoolhouse Bk	2,920	43.91615	–72.28400	SW, Sed	SW-03, SED-03	URS
SB-2940M	Schoolhouse Bk	2,940	43.91641	–72.28390	SW	SB-2	CRREL
SB-2960M	Schoolhouse Bk	2,960	43.91653	–72.28403	SW	LOC-51	ADL
SB-3020M	Schoolhouse Bk	3,020	43.91710	–72.28433	SW, Sed	SW-04, SED-04	URS
SB-3100M	Schoolhouse Bk	3,100	43.91751	–72.28493	SW, Tox	SB9, EMTT-6	EPA
SB-3125M	Schoolhouse Bk	3,125	43.91770	–72.28526	SW, B, F, Tox	Site 2, 06Ely19, SED7, SW-05, SED-05	USGS, EPA, URS

Table 1. Select characteristics for sampling locations at the Ely Mine study area, Vershire, VT.—Continued

[URS, URS Corporation; CRREL, U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory; ADL, Arthur D. Little, Incorporated; EPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; latitude and longitude are given in decimal degrees; SW, surface water; Sed, sediment; PW, pore water; B, benthic invertebrate; F, fish; Tox, toxicity test]

Site number	Stream	River meter[a]	Latitude	Longitude	Datasets	Historical name	Sampling organization
SB-3185M	Schoolhouse Bk	3,185	43.91806	–72.28583	F	F-18	ADL
SB-3220M	Schoolhouse Bk	3,220	43.91800	–72.28590	B	Ely Bk station 2.2	ADL
SB-3245M	Schoolhouse Bk	3,245	43.91847	–72.28625	Sed, Tox	ELYM-10-SS, EMTT-5	USGS, EPA
SB-3250M	Schoolhouse Bk	3,250	43.91837	–72.28634	SW, Sed	SW-06, SED-06	URS
SB-3255M	Schoolhouse Bk	3,255	43.91850	–72.28638	SW	SB8	EPA
SB-3260M	Schoolhouse Bk	3,260	43.91853	–72.28642	Sed	06Ely12	USGS
	Schoolhouse Bk	3,270	Confluence with Ely Brook				
SB-3290M	Schoolhouse Bk	3,290	43.91842	–72.28666	SW	SB-1, SW-38	CRREL, URS
SB-3300M	Schoolhouse Bk	3,300	43.91835	–72.28689	SW, Sed	LOC-48	ADL
SB-3320M	Schoolhouse Bk	3,320	43.91847	–72.28706	Sed, B	ELYM-9-SS, Ely Bk station 2.3	USGS, ADL
SB-3395M	Schoolhouse Bk	3,395	43.91833	–72.28778	F	F-19	ADL
SB-3510M	Schoolhouse Bk	3,510	43.91911	–72.28838	SW, Sed	SW-07, SED-07	URS
SB-3670M	Schoolhouse Bk	3,670	43.91951	–72.29015	SW, PW, Sed, B, F, Tox	Site 1, 06Ely05, SED6, EMTT-4	USGS, EPA
SBT1-6M	Schoolhouse Bk Trib	6	43.91609	–72.28405	SW, Sed	SW-25, SED-25	URS
SBT1-57M	Schoolhouse Bk Trib	57	43.91578	–72.28450	SW	LOC-50	ADL
OR-8350M	Ompompanoosuc River	8,350	43.80691	–72.25970	SW, Sed	LOC-45	ADL
OR-11800M	Ompompanoosuc River	11,800	43.83198	–72.25245	SW	OM14	EPA
OR-11850M	Ompompanoosuc River	11,850	43.83226	–72.25290	SW, Sed	LOC-35	ADL
OR-15000M	Ompompanoosuc River	15,000	43.84826	–72.25645	SW, F	OR-3, F-11	CRREL, ADL
OR-15200M	Ompompanoosuc River	15,200	43.85003	–72.25800	SW, Sed	LOC-56	ADL
OR-17400M	Ompompanoosuc River	17,400	43.86544	–72.26366	SW	LOC-55	ADL
OR-19150M	Ompompanoosuc River	19,150	43.87300	–72.26360	SW	LOC-54	ADL
OR-19560M	Ompompanoosuc River	19,560	43.88272	–72.26152	SW	OM13	EPA
OR-20200M	Ompompanoosuc River	20,200	43.88430	–72.25637	Sed	SED13	EPA
OR-22320M	Ompompanoosuc River	22,320	43.89595	–72.25971	Sed	SED12	EPA
OR-22390M	Ompompanoosuc River	22,390	43.89647	–72.25965	SW	OM12	EPA
OR-22450M	Ompompanoosuc River	22,450	43.89691	–72.25925	SW	OR-2	CRREL
OR-23200M	Ompompanoosuc River	23,200	43.90215	–72.26101	SW, PW, Sed, B, F, Tox	Site 3, 06Ely10, SED11	USGS, EPA
OR-23630M	Ompompanoosuc River	23,630	43.90521	–72.25854	SW, B, F, Tox	Site 2, 06Ely20, SW-28, SED-28	USGS, URS
	Ompompanoosuc River	23,640	Confluence with Schoolhouse Brook				
OR-23650M	Ompompanoosuc River	23,650	43.90541	–72.25855	SW, Sed	SW-26, SED-26	URS
OR-24050M	Ompompanoosuc River	24,050	43.90812	–72.25928	SW, PW, Sed, B, F, Tox	Site 1, 06Ely09, SED10, F-13	USGS, EPA, ADL
OR-24150M	Ompompanoosuc River	24,150	43.90915	–72.25990	SW	OR-1	CRREL
OR-24500M	Ompompanoosuc River	24,500	43.91132	–72.26134	SW, Sed	LOC-53	ADL
	Ompompanoosuc River	27,450	Confluence with Ompompanoosuc River Tributary				

Table 1. Select characteristics for sampling locations at the Ely Mine study area, Vershire, VT.—Continued

[URS, URS Corporation; CRREL, U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory; ADL, Arthur D. Little, Incorporated; EPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; latitude and longitude are given in decimal degrees; SW, surface water; Sed, sediment; PW, pore water; B, benthic invertebrate; F, fish; Tox, toxicity test]

Site number	Stream	River meter[a]	Latitude	Longitude	Datasets	Historical name	Sampling organization
ORT-1080M	Ompompanoosuc R Trib	1,080	43.93313	–72.27888	SW, Sed	SW-24, SED-24	URS
ORT-1150M	Ompompanoosuc R Trib	1,150	43.93301	–72.27968	SW, Sed	SW-23, SED-23	URS
ORT-1190M	Ompompanoosuc R Trib	1,190	43.93303	–72.28025	SW, Sed	SW-22, SED-22	URS
EM-SEEP1	Seep		43.92760	–72.28518	SW	ES-1	CRREL
EM-SEEP2	Seep		43.92662	–72.28455	SW	ES-2	CRREL
EM-SEEP3	Seep		43.92726	–72.28471	SW	ES-3	CRREL
EM-SEEP4	Seep		43.92694	–72.28427	SW	ES-4	CRREL
EM-SEEP5	Seep		43.92692	–72.28421	SW	ES-5	CRREL
EM-SEEP6	Seep		43.92675	–72.28313	SW	ES-6	CRREL
EM-SEEP7	Seep		43.92590	–72.28323	SW	ES-7	CRREL
EM-SEEP8	Seep		43.92583	–72.28424	SW	ES-8	CRREL
EM-SEEP9	Seep		43.92423	–72.28511	SW	ES-9	CRREL
EM-SEEP10	Seep		43.92328	–72.28525	SW	ES-10	CRREL
EM-SEEP11	Seep		43.92328	–72.28444	SW	ES-11	CRREL
EM-SEEP12	Seep		43.92709	–72.28565	SW	ES-12	CRREL
EM-SEEP13	Seep		43.92117	–72.28511	SW, Sed	SW-35, SED-35	URS
EM-SEEP14	Seep		43.92509	–72.28398	SW	SW-42	URS
EM-SEEP15	Seep		43.92645	–72.28414	SW	SW-43	URS
EM-SEEP16	Seep		43.92577	–72.28425	SW	SW-45	URS
EM-SEEP17	Seep		43.92657	–72.28456	SW	SW-46	URS
EM-SEEP18	Seep		43.92700	–72.28500	SW	SW-47	URS
EM-SEEP19	Seep		43.92698	–72.28561	SW	SW-48	URS
EM-SEEP20	Seep		43.92752	–72.28422	SW	SW-49	URS
EM-SEEP21	Seep		43.92438	–72.28499	SW	SW-52	URS

[a] River meter zero is located at the stream mouth.

software. A differential global positioning system (DGPS) location was output to the software each second. Sub-meter DGPS accuracy was achieved using a differential signal from the Wide Area Augmentation System (WAAS).

Stream morphology and substrate type were qualitatively assessed and are presented in appendix 1. Stream morphology (riffle, run, pool, or cascade) was determined as described in Fitzpatrick and others (1998). Emphasis was given to delineating areas of deposition. Substrate type (sand, gravel, cobble, or boulder) was qualitatively assessed in the field and determined on the basis of observed particle size as described by Arcement and Schneider (1989).

Sample locations were named using a river-meter method and an abbreviation for the particular reach (EB for Ely Brook, SB for Schoolhouse Brook, and OR for Ompompanoosuc River). The river-meter method refers to the sample location in distance upstream of the mouth, in meters. For example, EB-90M refers to a sample location on Ely Brook 90 meters upstream of the mouth.

Hydrologic Data

Instantaneous streamflow measurements were made at all water sampling locations. Streamflow was measured by the conventional current-meter method or by use of a portable Parshall flume using published USGS protocols (Buchanan and Somers, 1969; Rantz and others, 1982; Kilpatrick and Schneider, 1983). Error associated with a streamflow measurement made by the current-meter method in the Ompompanoosuc River and Schoolhouse Brook was calculated using protocols developed by Sauer and Meyer (1992). Error associated with a streamflow measurement made by the Parshall flume in Ely Brook was assumed to be equal to half the difference in the rated discharges per unit increase in observed stage. Error associated with streamflow measurements made by the current-meter method was less than 5 percent, and those made by Parshall flume were less than 15 percent.

Surface-Water Data

Surface-water samples were collected using standard USGS protocols (Wilde and Radtke, 1998; Wilde and others, 1999). Specific conductance, pH, and water temperature were determined by discrete measurements at the time of water-sample collection. Water samples were collected for the analysis of major ions, trace elements, nutrients, dissolved organic carbon, and suspended sediment. Samples were analyzed for major ions and trace elements by the USGS Analytical Chemistry Services Group in Denver, CO. Trace elements were analyzed using inductively coupled plasma–atomic emission spectroscopy (ICP-AES) and inductively coupled plasma–mass spectrometry (ICP-MS). Mercury was analyzed using continuous-flow cold-vapor atomic absorption spectrometry. Major anions were analyzed using ion chromatography. Samples for trace elements and major ions included a less than 0.45-micrometer (µm) filtered (dissolved) sample and an unfiltered (total) sample. Samples were analyzed for nutrients and dissolved organic carbon by the USGS National Water-Quality Laboratory in Denver, CO. Samples were analyzed for suspended sediments by the USGS Sediment Laboratory in Louisville, KY.

Pore-Water Data

Pore-water samples were obtained using three different methodologies. Pore water was extracted from sediment in situ using protocols described in Zimmerman and others (2005), extracted via centrifugation in the laboratory, and collected passively using separation by gravity from samples that aged or equilibrated 28 days in the laboratory. Pore-water physical properties and chemical data were collected using USGS protocols (Shelton and Capel, 1994). In situ pore-water samples were collected with the use of a push-point sampler at a depth of 15 centimeters (cm). A push-point sampler is designed to sample sediment pore water with minimal disturbance to the site. Specific conductance of sampled water was used to monitor gross chemical differences between surface water and pore water during sampling and to identify the presence of drawdown. Samples were analyzed for major ions and trace elements by the USGS Analytical Chemistry Services Group in Denver, CO. Trace elements were analyzed using ICP-AES and ICP-MS. Mercury was analyzed using continuous-flow cold-vapor atomic absorption spectrometry. Major anions were analyzed using ion chromatography. Samples for trace elements and major ions included a less-than-0.45-µm filtered (dissolved) sample and an unfiltered (total) sample. Samples were analyzed for nutrients and dissolved organic carbon by the USGS National Water-Quality Laboratory in Denver, CO. An aliquot of each pore-water sample collected by push-point sampling was submitted to the USEPA New England Regional Laboratory in North Chelmsford, MA, for use in 96-hour toxicity tests using *Chironomus dilutus* and *Hyalella azteca*. Methods and results of this testing are described in a report prepared by TechLaw under contract to the USEPA (TechLaw, Inc., 2006a).

Two additional types of samples were collected to evaluate pore-water chemistry. Subsamples of the sediments used for toxicity testing were centrifuged in the laboratory to obtain water for analysis. In addition, 2-L bottles were filled with sediments and topped off with stream water from the sample site. These samples were allowed to age or equilibrate in the lab for 28 days, at which point water was drained by gravity from the sediment sample for analysis.

Sediment Data

Streambed sediment samples were collected according to USGS protocols (Hammarstrom and others, 2003). Samples were collected in areas of deposition that coincided with pore-water sampling locations and analyzed for trace elements, simultaneously extractable metals–acid volatile sulfide (SEM-AVS), grain size, total organic carbon (TOC), cation-exchange capacity, and ash-free dry weight. Samples were collected from undisturbed, continuously wetted depositional zones in the stream channel. The top 10 cm of streambed sediment were sampled to obtain only the most recently deposited material. Composited samples were collected with 5 to 10 representative subsamples located across the stream channel. Samples were analyzed for trace elements using ICP-AES, TOC using an elemental analyzer, and mercury using continuous-flow cold-vapor atomic absorption spectrometry by the USGS Analytical Chemistry Services Group in Denver, CO. Samples were analyzed for SEM-AVS and grain size by Severn Trent Laboratory in Colchester, VT.

Potential sediment toxicity can be assessed either by comparing sediment geochemical concentrations to a probable effects concentration for various elements (PEC; MacDonald and others, 2000) or by investigating the equilibrium-partitioning sediment benchmark (ESB). The PEC for each chemical represents a concentration above which toxicity has been observed in toxicity tests from many sites. The ESB is defined as the molar difference between the combined simultaneously extractable metals (SEM; Cd + Cu + Ni + Pb + Zn) and the acid volatile sulfide (AVS), normalized to the fraction of organic carbon (OC) on a mass basis (f_{OC}; $[\Sigma SEM–AVS]/f_{OC}$; Di Toro and others, 2005; USEPA, 2005).

Macroinvertebrate Data

Macroinvertebrate samples were collected to coincide with water-chemistry sampling locations. The procedures in the USGS protocols for collecting biological samples (Moulton and others, 2002) were followed with some minor modifications described below that were based on State of Vermont protocols [Vermont Department of Environmental Conservation (VTDEC), 2006]. Because this study was designed to characterize the nature and extent of acid-mine drainage within the aquatic system, three different types of invertebrate samples were collected, each of which was specific to the habitat being sampled. The first of these samples was from areas representative of a riffle-targeted habitat (RTH) to characterize the effects of contaminants in surface water on invertebrate assemblage structure. The second of these samples was from areas representative of a depositional-targeted habitat (DTH), such as pools, to characterize the effects of contaminants in depositional sediments and interstitial pore water on invertebrate assemblage structure. At 10 of the 12 stream-reach locations, RTH and DTH samples were closely paired to assess the condition of the epifaunal (RTH) and infaunal (DTH) invertebrate assemblage. The purpose of using these two sample types was to determine if the degree of impairment from acid-mine drainage differed in the two assemblage types. The State of Vermont Bioassessment Program uses epifaunal assemblage data collected from riffle areas as the basis for stream assessments in lotic habitats (VTDEC, 2006), whereas the USEPA Superfund program emphasizes the ecological importance of assessing infauna in the depositional areas, because contaminated sediments tend to collect in the slow-flowing areas.

A third type of invertebrate sample, collected from the ponds, was a qualitative multi-habitat (QMH) sample. The QMH samples characterized the epifaunal invertebrate assemblages that were most closely associated with the vegetation along the littoral areas of the ponds, which typically supports assemblages with the greatest abundance and diversity in lentic systems.

RTH samples were collected using a Slack sampler with a 500-µm mesh designed to cover 0.25 square meter (m^2) of substrate area (Moulton and others, 2002). At each location, invertebrates were collected at four locations in a swift-flowing area of a sampling reach, and these four samples were composited to represent the invertebrate assemblage on a 1-m^2 area of substrate. This procedure is a slight deviation from the USGS protocol, which specifies a composite from five locations (1.25 m^2), but the change was made so that the assemblage data would conform to the method used by the VTDEC for high-gradient streams (VTDEC, 2006), and therefore be amenable to the bioassessment procedures used by VTDEC.

DTH samples of infaunal invertebrates were collected with a PVC coring device designed to sample the top 10 cm of sediment in an area of approximately 100 square centimeters (cm^2). At each location, sediments were sampled at five locations in depositional areas of a sampling reach, and these five samples were composited to represent the infaunal assemblage on a 500-cm^2 area of substrate. Sediment samples were collected by pushing the coring device into the sediment and then working a mason’s trowel through the sediment to close off the bottom.

QMH samples were collected in the littoral areas along the edges of the ponds that were dominated by vegetation, wood snags, or both, to characterize the invertebrate assemblage structure within the pond. The QMH samples were collected with an invertebrate kick-net sampler with a 500-µm mesh designed to cover 0.1 m^2 of substrate. At each location, a composite QMH sample was collected by making four sweeps of equal effort in each of four locations. Although these samples were designated as “qualitative,” using equal effort in collecting the samples resulted in an approximate relative-abundance measure that could be compared among locations (VTDEC, 2006).

Samples were preserved in 70-percent isopropyl alcohol and shipped to EcoAnalysts Inc., Moscow, ID, for taxonomic identifications and calculation of metrics of abundance, dominance, richness, composition, functional feeding groups, diversity/evenness, and biotic indices. A minimum of 300 individuals or 25 percent of the sample was counted and identified for each sample. The RTH data also were provided to VTDEC so that the agency could conduct a biological assessment of the data and determine the extent of impairment to the streams.

Fish Assemblage Data

Fish assemblages were surveyed in the field following USGS protocols (Crawford and Luoma, 1993; Moulton and others, 2002). Fish were collected by electrofishing with a backpack unit along the 100-m reach that was associated with each of the water-chemistry sampling location in Schoolhouse Brook (five locations) and the Ompompanoosuc River (three locations) (figs. 1 and 2). The fish surveys were conducted with the use of a single backpack unit in Schoolhouse Brook and with the use of two backpack units in the Ompompanoosuc River.[1] Fish were weighed, measured, and released, except for those specimens used for tissue samples for analysis of trace element concentrations. These fish were whole-body samples that used single fish for brook trout and composites of five to eight fish for blacknose dace. Fish tissue samples were freeze-dried, water loss during drying was measured, and samples were analyzed for trace elements using ICP-MS and for mercury using continuous-flow cold-vapor atomic absorption spectrometry by the USGS Analytical Chemistry Services Group in Denver, CO.

Toxicity Tests

Toxicity tests have been performed on surface water, whole sediment, and sediment pore water at the Ely Mine site. Surface-water toxicity testing using the water flea *Ceriodaphnia dubia* and the fathead minnow *Pimephales promelas* were performed at the USEPA New England Regional Laboratory in North Chelmsford, MA, in 2006. Methods and results are described by TechLaw, Inc. (TechLaw, Inc., 2006b). Whole sediment samples and pore water samples were collected at 10 sampling locations in August 2006. The toxicity of whole sediments was evaluated using 28-day exposures with the amphipod *Hyalella azteca* and 10-day exposures with the midge *Chironomus dilutus*, with endpoints of survival for both species, length of amphipods, and ash-free dry weight (AFDW) of midges. Tests were conducted and evaluated by the USGS Columbia Environmental Research Center (CERC) in Columbia, MO, according to standard methods for conducting whole-sediment toxicity tests (USEPA, 2000; ASTM, 2007) (appendix 1). Amphipod and midge exposures were conducted in 300-milliliter (mL) exposure chambers containing 100-mL sediment and 175-mL overlying water at 23 ± 1 °C. Tests with each of 11 Ely Mine sediments and one control sediment (a wetted soil from Florissant, MO) had 8 replicate chambers for each species, with 10 organisms in each chamber. Overlying water in test chambers was well water, diluted with deionized water to target hardness of 100 mg/L as $CaCO_3$. Overlying water in test chambers was renewed by an automatic water delivery system to deliver two volume replacements per day. Water quality of overlying water was monitored biweekly.

The toxicity of pore water was evaluated by USEPA as described by TechLaw, Inc. (TechLaw, 2006a). Pore waters for toxicity testing were extracted from each of the sediment samples by centrifugation and filtration (0.45 µm), and by in situ sampling. Aliquots of each sample were analyzed by the USGS Analytical Chemistry Services Group in Denver, CO. The toxicity of in situ pore waters was evaluated using 96-hour exposures with the amphipod *Hyalella azteca* and with the midge *Chironomus dilutus*, with endpoints of survival for both species.

In addition, toxicity testing also was done by USEPA for the ponds along the tributary to Ely Brook to the northeast. These tests included survival of fathead minnows and the hatching efficiency of wood frog (*Rana sylvatica*) eggs and the survival of their tadpoles (TetraLaw, Inc., 2008).

As an additional measure of risk within the ponds, USEPA performed in situ amphibian embryo-larval toxicity testing in 2007 (TechLaw, Inc., 2008). For these tests, wood frog egg masses were collected from an offsite reference pond and placed within enclosures in Ely Mine ponds 1, 4, and 5.

Quality-Control Procedures

Field quality-control procedures for samples collected in August 2006 included the collection of blanks and replicates for surface- and pore-water samples and replicates for sediment samples. Quality-control data for all media are presented in appendixes in 2, 3, and 4. Standard reference materials were submitted along with water and sediment samples. Field blanks provide information on bias or the potential for contamination of analytical results by sample collection, processing, and analysis (Spahr and Boulger, 1997). Concentrations of most constituents discussed in this report were below detection limits for the field-blank samples with the exception being zinc. Total zinc concentrations of 1.3 and 1.9 micrograms per liter (µg/L) were reported for surface- and pore-water field-blank samples. Field-replicate samples provide information on the variability of results (Spahr and Boulger, 1997). The absolute difference between environmental and replicate water samples for constituent concentrations discussed in this report ranged from 0 to 11 µg/L. Analytical laboratory quality-control procedures are summarized in Taggart (2002).

Data Analysis and Statistical Methods

Selected results from data in Argue and others (2008) and from this study are presented in the following sections and are shown as a series of graphs and plots used to analyze the data. For samples where multiple analytical methods were used, preference was given to the method with the lower reporting limit.

Chronic criteria standards for the protection of aquatic biota were used to compare trace-element concentrations in

[1] The Ompompanoosuc River location below the confluence of Schoolhouse Brook (OR-23200M) was resurveyed in August 2007 with a single backpack unit. The number of fish originally captured at this location in 2006 was lower than expected, which could be attributed to effects from acid-rock drainage, limited habitat features, or collection bias. Resurveying the location helped determine if abundance was affected by acid-mine drainage contamination (for example, if low abundance both times) or sampling efficiency (for example, if abundance was significantly higher when resurveyed).

water from data in Argue and others (2008) and from this study to water-quality guidelines and will be referred to as ambient water-quality criteria (AWQC). State of Vermont AWQC chronic criteria standards (VTAWQC) were used for analysis of As, Cd, Cr, Cu, Fe, Pb, Hg, Ni, Se, Ag, and Zn concentrations [Vermont Natural Resources Board (VTNRB), 2006]. The chronic toxicity standards for Cd, Cu, Pb, Ni, Ag, and Zn were adjusted based on hardness according to the VTAWQC (VTNRB, 2006). Hardness values for samples in this report were calculated from concentrations of Ca and Mg, in milliequivalents per liter (meq/L). The USEPA National Recommended Water Quality Criterion Continuous Concentration standard was used for analysis of total aluminum (Al) concentrations (USEPA, 2006). Tier II secondary chronic values summarized in Suter (1996) were used for analysis of dissolved concentrations of Sb, Ba, Be, Co, Mn, Sr, Tl, U, and V.

Consensus-based sediment quality guidelines developed by MacDonald and others (2000) were used to compare trace-element concentrations in stream sediment from this study to sediment-quality guidelines. The PEC was used for analysis of Cd, Cu, Pb, Ni, and Zn (MacDonald and others, 2000). Sediment toxicity is also assessed using the ESB (Di Toro and others, 2005; USEPA, 2005).

Water and sediment toxicity analysis was done using the hazard quotient (HQ) and hazard index (HI) methods (USEPA, 1986). The HQ is a ratio of the measured trace-element concentration to the chronic toxicity standard for that element. Trace elements with an HQ value greater than 1 have the potential to be toxic to aquatic communities. The HI is a sum of the HQ values for select constituents at each location and was used to describe the potential cumulative effect of contaminants on aquatic communities. Because of their concentrations in the water, and sediment, their inclusion in the simultaneously extractable metals fraction, and their toxicity to aquatic biota, Cd, Cu, Pb, Ni, and Zn were used to calculate HI in this report.

A statistical analysis of water data in Argue and others (2008) and analysis of instantaneous constituent loads from the August 2006 samples were conducted to investigate the origin and transport of potential contaminants at the Ely site. Summary statistics for surface-water data were analyzed by SAS/STAT software (version 9.1; SAS Institute, Inc., 1998) and robust regression on order statistics (ROS), which uses a probability plot of the logarithms of data to account for datasets that includes multiple detection limits (Helsel and Cohn, 1988; Helsel, 2005). The Kruskal-Wallis statistical test, a non-parametric analysis of variance (ANOVA) test that uses ranked data, was performed using SAS/STAT statistical software (SAS Institute, Inc., 1998) to determine if there were statistical differences among Ely Brook tributaries, Ely Brook, Schoolhouse Brook, the Ompompanoosuc River, and background conditions. The level of significance for ANOVA was set at alpha equal to 0.05. If a significant difference was found, the Tukey's multiple-comparison test was used to determine which groups differed significantly (Helsel and Hirsch, 1992). Results of this analysis were examined among stream reaches and background locations by use of box plots. Results below the maximum detection limit used in each analysis were considered estimated, and box plots for these values were expressed as dashed lines (Helsel, 2005).

The RTH invertebrate and fish survey data were provided to the VTDEC Water Quality Division, which analyzed the data as specified in their bioassessment protocols for wadeable streams and rivers (VTDEC, 2004) to determine the extent of impairment to the locations. The assessment of the ecological condition of a location was based on how the invertebrate or fish assemblage scored among several metric categories that characterized assemblage structure and function. A fish-assemblage assessment was indicated numerically from an index of biotic integrity (IBI), which was based on compiled scores of the individual structure and function metrics. Assessments based on RTH invertebrate assemblages did not rely on an IBI, but instead, each of eight metrics was scored against threshold values for pass, fail, or intermediate; the comprehensive assessment for each location is then based on a compilation of the eight qualitative scores. Depending how the invertebrate assemblage scored over the eight metrics, or how the fish assemblage scored with the IBI, the assessment was qualitatively summarized as poor, fair, good, very good, or excellent, which is pertinent to Vermont Class B water-quality standards. At the time of this study, VTDEC did not have an established protocol for assessing sites with DTH and QMH data.

Differences in fish assemblages among the locations were measured in two ways, both of which used the fish IBI to represent the assemblage condition at each location: The IBI scores were compared along the stream gradient (upstream to downstream) to determine where effects from acid-rock drainage likely occurred, the relative impairment across sites, and if there was a trend toward recovery; secondly, the IBI scores were compared against the HI values to characterize changes in condition along a contamination gradient. Differences in invertebrate assemblages also were measured over stream and contaminant gradients, but assemblage characterizations were not based on a common IBI because different types of samples were collected (RTH, DTH, QMH) and the VTDEC bioassessment procedure of a qualitative ranking only applied to the RTH samples. The assessment for the RTH samples did not derive a single IBI for direct comparison but used a qualitative ranking. Therefore, two of the eight metrics used in bioassessments by VTDEC were used to characterize biological condition of the sites: invertebrate abundance and richness (total number of individuals and total number of taxa, respectively). Values of these two metrics were determined for all of the invertebrate sample types (RTH, DTH, QMH) to serve as a common baseline for comparison of all locations. When comparing changes in fish and invertebrate assemblages across sites, reference baselines were the fish IBI scores and invertebrate abundance and richness values from the most upstream location in the respective system (EB-1080M, SB-3670M, Ely pond 1, OR-24050M).

Fish-tissue data were compared to the critical body residue of metals that were used to derive the HI for Cd, Cu, Pb, Ni, and Zn, and additionally for Hg. For a particular fish species, a critical body residue (CBR) is a literature-based benchmark that represents a metal concentration in the tissue at which adverse effects have been observed (effects level), or below which an adverse effect was not observed (no observable effects level). In this study, the critical body residues were based only on literature values for no-effect and effect levels in salmonids because brook trout (a salmonid) is a species of special interest in the waterways affected by the Ely Mine, and also because no relevant data were found for blacknose dace or any other cold-water cyprinid. The salmonid critical body residue values were compared to metal concentrations in the samples of single brook trout. However, brook trout were only captured at three sites (SB-3670M, SB-3100M, OR-23200M), whereas blacknose dace were captured at all eight fish-survey sites. Thus, the brook trout critical body residue values were also compared to those for the composite samples of blacknose dace to provide a more comprehensive view of the study area.

Toxicity data were analyzed by SAS/STAT software (version 9.1). Toxicity data were transformed to ranks before ANOVA testing. Overall ANOVA tests were conducted to determine whether test endpoints differed significantly among all sediments tested (rho < 0.05). For endpoints with significant overall ANOVA tests, separate ANOVA tests were conducted with sediments from each of the three streams (Ely Brook, Schoolhouse Brook, and the Ompompanoosuc River) with the one-tailed Dunnett's test used to determine which responses were significantly less than those in reference sediments from each stream.

Description of Study Area

Mine Site

The Ely Mine site is located within the Vermont copper belt in Vershire, Orange County, VT; it is approximately 1,800 acres (730 ha) in size, and contains piles of waste rock, ore waste, tailings, and smelter waste. Waste-rock and tailings piles extend from an area downgradient of the main shaft to the center of the site, whereas ore and smelter wastes are located near the southern boundary (fig. 2).

Surface waters at the mine site drain primarily to Ely Brook. Ely Brook originates upgradient and northwest of the mine site, generally flows north to south, and is west of the mine workings and waste piles (fig. 2). A short tributary to Ely Brook originates northeast of the mine site and flows through a series of small ponds before crossing waste-rock piles and joining the main stem of Ely Brook. Waters from Ely Brook flow into Schoolhouse Brook which, in turn, flows for approximately 3,270 meters to the confluence with the Ompompanoosuc River (figs. 1 and 2).

The predominant land use of the study area is forest, and approximately 37 percent of the Ompompanoosuc River basin above the confluence with the West Branch is mixed forest (table 2) (Olson and others, 2005). However, in the Ely Brook basin, the percentage of mixed forest decreases to less that 20 percent. Locally, the mean annual temperature is 5.6 °C, mean summer temperature is 15 °C, and mean annual precipitation varies with altitude and ranges from 91 to 102 cm (table 2) (Olson and others, 2005).

Ely Brook

Ely Brook has a total drainage area of 1.11 km^2, stream reach of approximately 1,500 m, and a range in altitude from approximately 296 to 383 m. The surficial geology of the basin is predominantly till (fig. 3). A qualitative geomorphic characterization of a stream segment from river meter 0 to 1,080 found the distribution of geomorphic channel units to be approximately 45 percent riffle, 42 percent run, and 13 percent pool. Two distinct patterns in the geomorphology were also present: the channel above river meter 440 was dominated by boulder and woody debris riffles and had an average channel slope of 11 percent, whereas the channel below river meter 440 was dominated by gravel riffles and sand runs and had an average channel slope of 1.5 percent. Channel slope for 100-m reaches at each of the sampling locations ranged from 1.8 percent to 14.6 percent (table 2). Ely Brook is categorized as a small high-gradient stream by the State of Vermont, based on the stream classifications that are used in the bioassessment protocols developed for fish and invertebrate assemblages in Vermont (VTDEC, 2004).

Four tributaries flow into Ely Brook from the east, come in contact with mine wastes, and have the potential to discharge trace elements and acidity to Ely Brook. Ely Brook tributary 1, which may be intermittent, discharges to Ely Brook at river meter 350 and is downgradient from ore waste and roasting beds. Ely Brook tributary 2 drains a series of ponds located in the northeast section of the site, flows over a waste-rock pile in the center of the site, and discharges to Ely Brook at river meter 540. Ely Brook tributary 2 was referred to as East Branch Ely Brook by Cherau and others (2005). Ely Brook tributary 3 originates downgradient of the main shaft, flows north to south over waste rock piles, and discharges to Ely Brook tributary 2 at river meter 10. Ely Brook tributary 4, which may be intermittent, originates downgradient of mine shaft 4 and discharges to Ely Brook at river meter 800. In addition, tributary 2 has a small tributary, tributary 5, that drains a small area to the east of tributary 2 and has been sampled by various studies.

A series of six ponds drain the eastern slope of the Ely Brook basin and form the headwaters for Ely Brook tributary 2 (fig. 2). The ponds range in size from approximately 35 m^2 (pond 6) to 3,800 m^2 (pond 1) and are located at Ely Brook tributary 2 river meter 195 (pond 6), 290 (pond 5), 320 (pond 4), 345 (pond 3), 385 (pond 2), and 432 (pond 1). Pond 1, contained behind an earthen dam, is believed to have been a water-supply reservoir constructed some time between 1882 and 1899 (Cherau and others, 2005). The pond is fed

Table 2. Select basin and reach characteristics for sampling locations at the Ely Mine study area, Vershire, VT.

[km^2, square kilometer; m, meter; cm, centimeter; %, percent; °C, degrees Celsius; SHG, small high gradient; CWIBI, coldwater index of biotic integrity; MHG, medium-size high gradient; MWIBI, mixed water index of biotic integrity]

Characteristic	Ely Brook (River meter)					
	0[a]	90	600	770	1,080	
Basin						
Drainage area (km^2)	1.11	1.06	0.44	0.36	0.22	
Elevation (m)		297	313	329	370	
Lakes/Ponds (%)	.13	.13	.00	.00	.00	
Annual precipitation (cm)	97.8					
Coniferous forest (%)	1					
Mixed forest (%)	17					
Mean temperature (°C)	5.6					
Mean summer temperature (°C)	15.0					
Strahler stream order	1	1	1	1	1	
Reach						
Canopy (%)		100	100	100	100	
Channel slope		.018	.095	.130	.146	
Riffle (%)	45	69	36	42	94	
Run (%)	42		41	58	6	
Pool (%)	13	31	23			
VT Macroinvertebrate Category	SHG	SHG	SHG	SHG	SHG	
	Schoolhouse Brook (River meter)					
	0[a]	140	1,360	2,400	3,125	3,670
Basin						
Drainage area (km^2)	25.2	25.2	24.7	19.4	15.6	14.2
Elevation (m)		212	238	273	291	305
Lakes/Ponds (%)	.04	.04	.04	.05	.06	.05
Annual precipitation (cm)	101					
Coniferous forest (%)	8					
Mixed forest (%)	28					
Mean temperature (°C)	5.4					
Mean summer temperature (°C)	14.8					
Strahler stream order	2	2	2	2	2	2
Reach						
Canopy (%)		25	25	50	20	10
Channel slope		.005	.025	.024	.028	.030
Riffle (%)	95	69	94	77	100	82
Run (%)	3					
Pool (%)	2	31	6	23		18
VT Macroinvertebrate Category	SHG	SHG	SHG	SHG	SHG	SHG
VT Index of Biotic Integrity	CWIBI	CWIBI	CWIBI	CWIBI	CWIBI	CWIBI
	Ompompanoosuc River (River meter)					
	8,350[a]	23,200	23,630	24,050		
Basin						
Drainage area (km^2)	168	51.0	76.9	77.4		
Elevation (m)		240	242	243		
Lakes/Ponds (%)	1.41	.09	.09	.11		
Annual precipitation (cm)	93.7	101				
Coniferous forest (%)	16	8				
Mixed forest (%)	37	29				
Mean temperature (°C)	5.7	5.3				
Mean summer temperature (°C)	15.2	14.7				
Strahler stream order	4	3	3	2		
Reach						
Canopy (%)		50	25	40		
Channel slope		.005	.005	.005		
Riffle (%)	39	39	60	89		
Run (%)	51	36	40			
Pool (%)	11	25		11		
VT Macroinvertebrate Category	MHG	MHG	MHG	MHG		
VT Index of Biotic Integrity	MWIBI	MWIBI	MWIBI	MWIBI		

[a] Reach characteristics are a summary of results from a habitat assessment conducted in June 2006 (appendix 1).

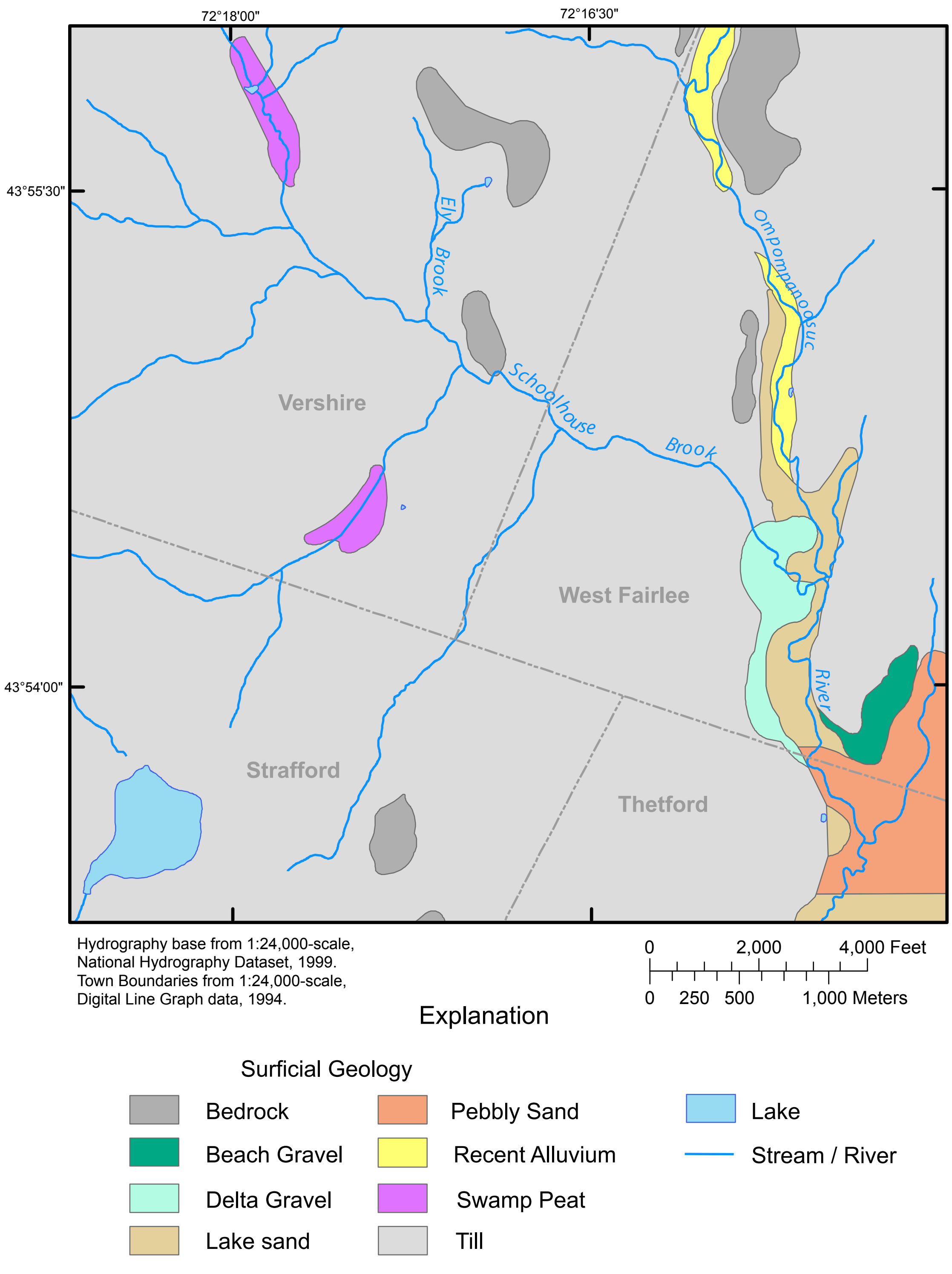


Figure 3. The surficial geology of the Ely Mine Superfund site study area, VT.

by an intermittent stream that drains from the east and possibly by a spring (Cherau and others, 2005). Ponds 2 through 5 appear to be the result of beaver dams created along Ely Brook tributary 2. Pond 6, however, is a depression formed in a short exploration shaft, or other type of abandoned mine-development excavation. Two small, intermittent streams drain into the pond system below pond 1: one stream flows into pond 2 from the northeast, and one stream flows adjacent to a waste-rock pile and into pond 5 from the north. A groundwater seep also is present upgradient of pond 4.

Schoolhouse Brook

Schoolhouse Brook has a total drainage area of 25.2 km^2, stream reach of approximately 7,650 m, and a range in altitude from approximately 210 to 480 m. Two tributaries flow into Schoolhouse Brook below the confluence with Ely Brook, at approximately river meter 2,100 and river meter 2,915. The contributing drainage area for these tributaries is 7.1 km^2.

The surficial geology of the basin is predominantly till (fig. 3). However, the surficial geology underlying the stream channel from river meter 0 to 600 is characterized as being delta gravel and lake sand. A qualitative geomorphic characterization of the stream segment from river meter 0 to 3,670 found the distribution of geomorphic channel units to be approximately 95 percent riffle, 3 percent run, and 2 percent pool. The average slope for this stream segment is 2.6 percent. Below river meter 600, however, the distribution of riffle, run, and pool environments becomes more sequential as the channel slope decreases to approximately 1 percent. Channel slope for 100-m reaches at each of the sampling locations ranged from 0.5 to 3.0 percent (table 2). Schoolhouse Brook is categorized as a small high-gradient stream, which is characteristic of a stream that could support a cold-water fishery (VTDEC, 2004). Therefore, when assessing the condition of fish assemblages, in Schoolhouse Brook, an IBI designed for coldwater fish (CWIBI) was used to indicate the relative degree of impairment to the assemblages.

Ompompanoosuc River

The Ompompanoosuc River above the confluence with the West Branch of the Ompompanoosuc River has a total drainage area of 168 km^2. The surficial geology of the basin is predominantly till (fig. 3). However, the surficial geology underlying the stream channel in the study area is characterized as delta gravel, lake sand, and pebbly sand. A qualitative geomorphic characterization of a stream segment from river meter 20,300 to 24,200 found the distribution of geomorphic channel units to be approximately 39 percent riffle, 51 percent run, and 10 percent pool. The average slope for this stream segment is 0.5 percent. Two distinct patterns in the geomorphology were present: the channel above river meter 23,640 was dominated by boulder and cobble riffles and had an average channel slope of 0.5 percent, whereas the channel below river meter 23,640 was dominated by gravel riffles and sand runs and had an average channel slope of 0.2 percent. Channel slope for 100-m reaches at each of the sampling locations was 0.5 percent (table 2). The Ompompanoosuc River is categorized as a medium high-gradient stream with a mixed water fishery; therefore, a mixed water IBI (MWIBI) was used to indicate the relative degree of impairment to the fish assemblages (VTDEC, 2004).

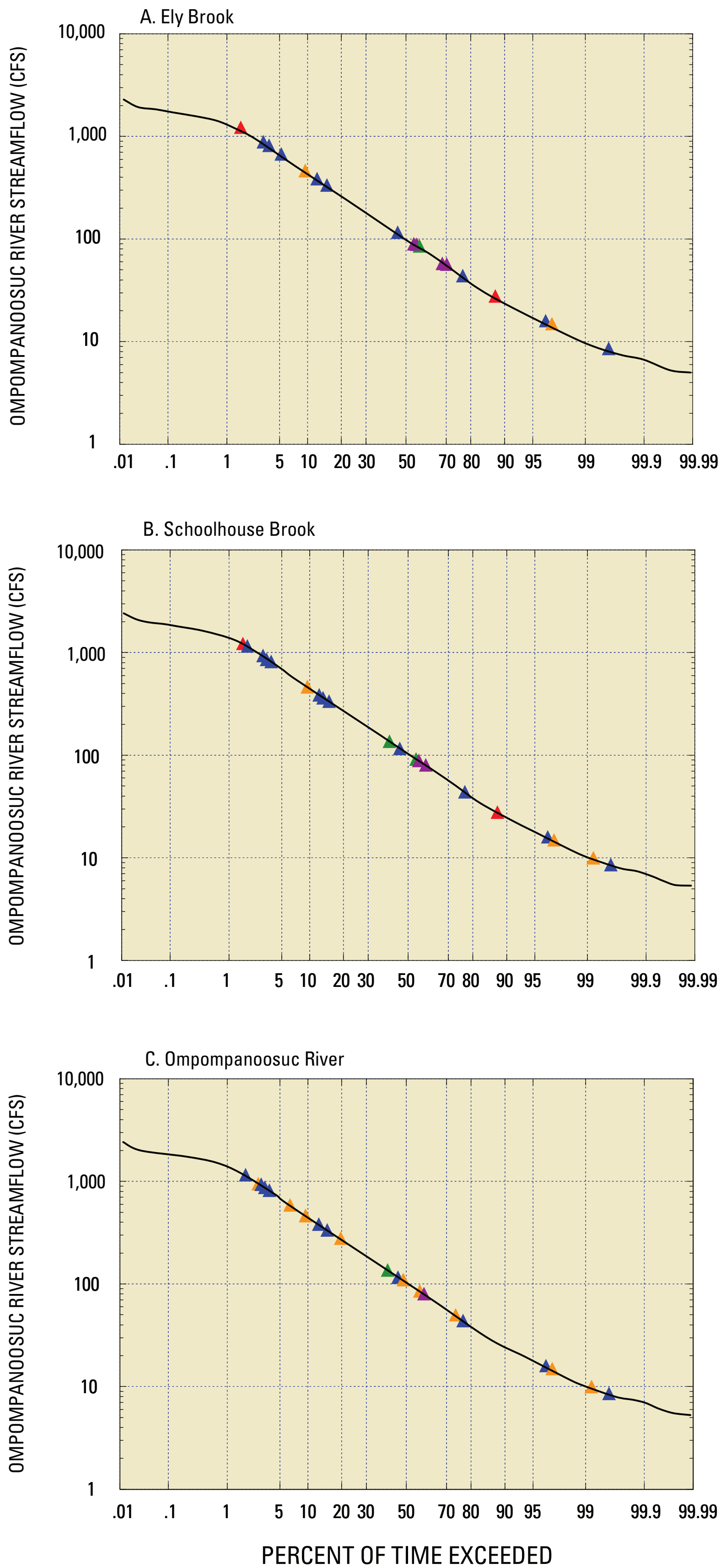
Nature and Extent of Contamination

Acid-mine drainage occurs when sulfide-bearing waste rock and tailings come in contact with waters containing dissolved oxygen. The resulting oxidation reactions release associated metals and acidity, which may impact the biological community and significantly lower the pH of downstream waterways. Released metals that are transported downstream may be removed from solution through precipitation of and sorption onto iron and manganese hydroxides (Harvey and Fuller, 1998; Tonkin and others, 2004). Attenuation of metals also has been attributed to precipitation and sorption within the hyporheic zone as contaminated waters infiltrate and mix with shallow groundwater (Harvey and Fuller, 1998; Fuller and Harvey, 2000).

Waste rock and tailings at the Ely Mine site have similar mineralogy and chemistry and leach comparable metal concentrations and acidity to those observed at the Elizabeth and Pike Hill mines (Seal and others, 2001; Piatak and others, 2004, 2006). The weathering of mine wastes in the Vermont copper belt has been shown to produce concentrations of metals in downstream waterways greater than those allowed by USEPA acute and chronic standards (Holmes and others, 2002; Kiah and others, 2007).

Surface-water samples have been collected at 103 stream and 21 seep locations in the study area (table 1) (Argue and others, 2008). Concentrations greater than AWQC were observed for 15 elements: Al, Ba, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, U, and Zn (appendix 5). These results are similar to those of Piatak and others (2004), who showed the bulk geochemistry of Ely Mine waste comprised Fe $>>$ Al $>$ S $>$ K $>$ Ca, and trace elements comprised Cu $>$ Mn $>$ Ba $\approx$ U $\approx$ Zn $>$ Cr $>$ Sr $>$ Co $\approx$ Mo $\approx$ Pb, on a mass basis. Leach tests performed on the mine waste also found Cd, Co, Cu, Ni, and Zn to be the dominant elements released (Piatak and others, 2004).

Surface-water data were compared to regional streamflow characteristics computed for the Ompompanoosuc River at Union Village, VT (USGS station 01141500) to investigate the distribution of water samples relative to expected streamflows in the basin. A cumulative frequency duration curve showing the percentage of time that a given daily mean streamflow is expected to be equaled or exceeded at USGS station 01141500 and the distribution of water samples in each stream reach, relative to the various daily mean streamflows observed at station 01141500, are shown in figure 4. Based on



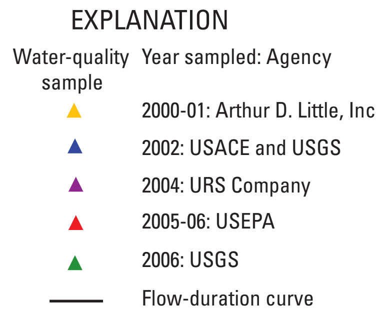


Figure 4. Flow-duration curve for U.S. Geological Survey gaging station 01141500 Ompompanoosuc River at Union Village Dam, VT, with streamflow distribution of water-quality samples collected in *(A)* Ely Brook, *(B)* Schoolhouse Brook, and *(C)* the Ompompanoosuc River. Flow-duration curve was based on daily mean streamflows for period 1949–89. Water-quality samples reflect days that data were collected and not individual samples. CFS, cubic feet per second.

this analysis, surface-water samples were well distributed over the expected range in streamflows, as greater than 95 percent of the streamflows that may be expected at the site were represented by a water sample (fig. 4). Furthermore, 95 percent of the streamflows associated with the samples were within 2 standard deviations of the mean, and the median probability of exceedence for the dataset was 52 percent, indicating an equal distribution of water samples across expected streamflows. Water samples collected in August 2006 ranged from a probability of exceedence of about 40 percent on August 21 to about 55 percent on August 23 as samples were collected over the course of a recession in streamflow.

Surface water, pore water, sediment, invertebrates, and fish were sampled to define potential areas of impact from acid-mine drainage, to assess the ability of the streams to attenuate contaminants, and to identify the fraction of contaminants that may be bioavailable. Surface water and invertebrates were sampled at 12 stream sites in August 2006 and 6 pond sites in September 2006 (figs. 1 and 2, table 1). Pore water and sediment were sampled at 10 stream sites in August 2006. Fish were sampled at eight stream sites in September 2006 (table 3). Physical parameters for surface- and pore-water samples are listed in tables 4 and 5.

A preliminary analysis was conducted to determine if the biological assemblages (RTH, DTH, QMH invertebrates, and fish) were more strongly correlated to values of metal concentrations from surface water, pore water, or sediment. This analysis was not especially relevant for the Ompompanoosuc River locations because pore-water and sediment samples were collected at only two sites (that is, |rho| = 1). However, the results for Ely Brook, Schoolhouse Brook, and the Ely ponds indicated that the metal concentrations in the surface-water samples were most strongly correlated with the QMH, RTH, and fish samples, and metal concentrations in the pore-water samples were most strongly correlated with the DTH samples. These results are exemplified in the Spearman rho values from correlations of in situ pore water, surface water, and sediment-metal concentrations with the total richness for invertebrates and the IBI score for fish (table 3). Based on these results, the analyses of biological data below relate a particular biological assemblage with the metal concentrations in the sample that is most directly associated with the assemblage (RTH, QMH, fish with surface-water metals; DTH with pore-water metals).

Background Conditions

Surface-Water Geochemistry

Sites in the study that are considered to represent background conditions with respect to historical mining are those water-quality sites upstream from any known mining disturbance. These sites include EB-1080M for Ely Brook, pond 1 for the northeastern tributary 2 to Ely Brook, SB-3670M for Schoolhouse Brook, and OR-24050M for the Ompompanoosuc River. Data from these sites from this study will be used as a basis for comparison with results from previous studies to gain insights into longer term variability of background water quality. Field parameters and chemical constituents for surface-water samples are summarized in table 4, and complete analyses are reported in appendix 6.

Field Parameters and Major Inorganic Constituents

The gross chemical properties of the background water samples vary according to the size of the catchment area. Previous reports found similar results (Seal and others, 2001; Holmes and others, 2002; Argue and others, 2008). The headwaters of Ely Brook (EB-1080M and pond 1) in the vicinity of the mine have lower pH and specific conductance values than the receiving streams, Schoolhouse Brook (SB-3670M) and the Ompompanoosuc River (OR-24050M). The pH of the

Table 3. Spearman rho values from correlating metal concentrations measured in surface water (SW), in situ pore water (PW), and sediment (SED) against invertebrate richness (RTH, QMH, and DTH samples) and against the index of biotic integrity scores for the fish surveys. The RTH, QMH, and fish data were more strongly correlated to metals in SW (**bold** rho values) than to PW or SED. The DTH data were more strongly correlated to metals in PW (**bold** rho values) than to those in SW.

[RTH, riffle-targeted habitat; QMH, qualitative multi-habitat; DTH, depositional-targeted habitat; —, no value]

Sample type	Spearman rho value								
	Ely Brook			Schoolhouse Brook			Ely Ponds		
	SW	PW	SED	SW	PW	SED	SW	PW	SED
RTH (streams) or QMH (ponds)	**–1.000**	–0.800	–0.800	**–0.821**	–0.632	–0.200	**–0.886**	—	–0.657
DTH	–0.634	**–0.949**	–0.949	–0.316	**–0.949**	–0.400	—	—	—
FISH	—	—	—	**–0.764**	–0.632	–0.200	—	—	—
Number of samples	4	4	4	5	4	4	6	—	6

Table 4. Constituents in filtered surface waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.

[The concentrations of the following elements were below their detection limits (given in parentheses in micrograms per liter, µg/L): Ag (<3), As (<1), Hg (<5), Mo (<2), Se (<1), Tl (<0.1), and V (<0.5). S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; —, not determined; <, analyte not detected at the reporting level]

Stream and location	pH	S.C. (µS/cm)	Alkalinity (mg/L as $CaCO_3$)	DOC (mg/L)	N (mg/L)	P (mg/L)	Ca (mg/L)	Fe (µg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	SiO_2 (mg/L)	Al (µg/L)	Ba (µg/L)	Be (µg/L)
Ely Brook															
EB-1080M	7.2	87	41	1.9	0.07	0.003 E[a]	13.4	22	1.69	1.18	1.12	9.1	3.4	18.4	<0.05
EB-770M	6.3	149	11	0.8	0.04 E	0.002 E	17.2	<20	2.43	3.2	1.64	17.2	25.1	19.9	0.06
EB-600M	7.0	123	16	0.9	0.05 E	<0.004	14.9	<20	2.17	2.43	1.44	13.7	20.7	17	<0.05
EB-90M	3.2	447	—	1.6	0.07	0.004 E	21.1	6370	3.42	5.54	2.3	33.1	4,190	19	0.3
Ely Ponds															
EM-POND1	7.0	51	19	3.5	0.46	0.036	5.77	66	1.67	1.07	1.2	2.2	15.8	9.61	<0.05
EM-POND2	6.5	65	27	2.6	0.22	0.011	7.67	353	1.78	1.11	1.34	4.6	6.5	13.5	<0.05
EM-POND3	6.7	70	31	2.6	0.25	0.006	8.72	253	1.75	1.17	1.3	5.1	6.2	12.5	<0.05
EM-POND4	6.7	78	30	2.2	0.19	0.007	9.7	105	1.86	1.37	1.32	5.5	5.5	18.6	<0.05
EM-POND5	6.5	117	17	1.4	0.11	0.003 E	13	<20	2.13	2.44	1.41	9.2	10.1	13.7	<0.05
EM-POND6	4.7	206	—	1.1	0.1	0.006	18.6	565	2.54	4.17	1.6	14.8	1,410	13.2	0.2
Schoolhouse Brook															
SB-3670M	8.2	212	99	1.2	0.08	0.002 E	35.7	<20	2.26	1.71	3.89	7.3	12.8	20.5	<0.05
SB-3125M	7.8	215	89	1.3	0.11	0.005	35.1	49	2.34	1.99	4.16	8.9	124	19.8	<0.05
SB-2400M	8.3	210	89	1.2	0.09	0.003 E	35.8	<20	2.42	2.03	4.62	9.1	128	18.5	<0.05
SB-1360M	7.9	203	86	1.5	0.09	0.003 E	33.8	13	2.29	1.95	4.27	8.6	84.4	18.4	<0.05
SB-140M	8.2	186	80	2	0.12	0.006	30.7	20	2.2	1.82	3.77	8.5	93.5	14.8	<0.05
Ompompanoosuc River															
OR-24050M	8.0	196	88	2.5	0.21	0.007	32	<20	2.16	1.46	5.22	7.2	13.4	19.9	<0.05
OR-23630M	8.0	198	87	2.6	0.2	0.006	32.9	<20	2.23	1.55	5.45	7.6	23.3	20.2	<0.05
OR-23200M	8.1	196	85	2.6	0.2	0.005	32.6	<20	2.24	1.61	5.15	7.8	44.6	19.1	<0.05

Stream and location	Cd (µg/L)	Co (µg/L)	Cr (µg/L)	Cu (µg/L)	Mn (µg/L)	Ni (µg/L)	Pb (µg/L)	Sb (µg/L)	Sr (µg/L)	U (µg/L)	Zn (µg/L)	NO_3 (mg/L)	SO_4 (mg/L)
Ely Brook													
EB-1080M	<0.02	0.08	<1	1.3	124	0.5	<0.05	<0.3	47.6	<0.1	5.6	<.08	4.3
EB-770M	0.95	31.1	<1	837	217	12.1	0.1	<0.3	62.3	<0.1	114	0.5	52
EB-600M	0.48	12.5	<1	211	92.8	6.4	0.06	<0.3	52.6	<0.1	64.2	0.5	36
EB-90M	1.99	63	2.1	1,560	521	19.5	0.95	<0.3	64	0.42	373	1	143
Ely Ponds													
EM-POND1	<0.02	0.03	<1	1.1	2.7	<0.4	0.09	<0.3	20.5	<0.1	2.3	<.08	6.3
EM-POND2	<0.02	0.13	<1	2.9	201	0.4	0.08	<0.3	29.5	<0.1	11.5	0.6	5.4
EM-POND3	<0.02	0.23	<1	1.7	435	0.6	0.1	0.62	34.8	<0.1	2.4	0.6	5
EM-POND4	0.08	0.41	<1	13.4	212	1.3	0.1	<0.3	38.2	<0.1	14.8	<.08	8.1
EM-POND5	1.02	20.4	<1	444	386	7.7	<0.05	<0.3	43.4	<0.1	143	0.6	33
EM-POND6	2.28	46.3	<1	1,380	564	16.7	0.4	0.52	50.4	0.2	325	0.6	93
Schoolhouse Brook													
SB-3670M	<0.02	<0.02	<1	<0.5	5.6	<0.4	0.05	<0.3	166	0.32	2.8	0.6	9
SB-3125M	0.12	4.31	<1	42.8	43.8	1.5	0.07	0.78	157	0.31	15.6	0.6	13
SB-2400M	0.08	2.82	<1	25	31.5	1.2	<0.05	<0.3	158	0.3	6.6	0.6	16
SB-1360M	0.07	1.94	<1	21.6	19.1	1.1	<0.05	<0.3	152	0.27	19.8	0.5	14
SB-140M	0.05	1.1	<1	20.4	13.6	1	0.1	<0.3	134	0.24	12.8	0.5	13
Ompompanoosuc River													
OR-24050M	<0.02	<0.02	<1	0.84	4.7	<0.4	0.08	<0.3	138	0.24	9.3	0.6	7.2
OR-23630M	0.02	0.11	<1	3.3	7.1	<0.4	0.06	<0.3	139	0.24	12.5	0.6	8
OR-23200M	0.1	0.31	<1	8.9	8.9	0.5	0.2	<0.3	139	0.24	6.9	0.5	8

[a] Estimated value, reported concentration is less than the reporting level but greater than the long-term method-detection level.

Table 5. Constituents in filtered pore waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.

[The concentrations of the following elements were below their detection limits (given in parentheses in micrograms per liter, µg/L): Ag (<3), As (<1), Hg (<5), and Mo (<2). S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; —, not determined; <, analyte not detected at the reporting level; ins, insufficient sample]

Stream and location	Sample type	pH	S.C. (µS/cm)	Alkalinity (mg/L as $CaCO_3$)	DOC (mg/L)	N (mg/L)	P (mg/L)	Ca (mg/L)	Fe (µg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	SiO_2 (mg/L)	Al (µg/L)	Ba (µg/L)	Be (µg/L)
Ely Brook																
EB-1080M	in situ	7.1	85	40	1.6	0.08	0.003 E[a]	12.6	<20	1.68	1.18	1.13	9	4.3	16.6	<0.05
EB-1080M	centrifuge	—	—	—	—	—	—	28	436	2.78	2.53	1.71	9.7	88.8	33.4	<0.05
EB-1080M	equilibrated	7.5	389	204.8	—	—	—	69.5	<20	4.84	6.42	2.79	12.7	12.2	74.7	<0.05
EB-770M	in situ	6.1	131	11	1	0.04 E	<0.004	14.3	145	2.16	2.41	1.41	12.8	4.8	12.9	<0.05
EB-770M	centrifuge	—	—	—	—	—	—	32	32	3.45	5.38	1.95	15	50.4	31.9	<0.05
EB-770M	equilibrated	6.0	400	39.6	—	—	—	56.1	747	7.32	9.29	3.51	25.3	7	64.5	<0.05
EB-600M	in situ	6.9	119	15	1	0.05 E	0.004 E	14.4	<20	2.13	2.29	1.4	13	7.1	17	<0.05
EB-600M	centrifuge	—	—	—	—	—	—	16.8	52	2.6	2.56	1.47	12.4	345	19.8	<0.05
EB-600M	equilibrated	7.0	164.2	30.4	—	—	—	21.6	<20	4.04	3.16	2.4	15.9	15.4	26.7	<0.05
EB-90M	in situ	2.9	594	—	1.3	0.17	0.004	20.4	11,000	4.87	5.43	2.34	32.8	3,060	17.8	0.3
EB-90M	centrifuge	—	—	—	—	—	—	29.1	163,100	10.3	8.58	5.42	69.8	7,520	20.6	0.3
EB-90M	equilibrated	3.2	1063	—	—	—	—	28.7	47,000	5.24	7.61	4.23	39.5	6,050	21.8	0.5
Schoolhouse Brook																
SB-3670M	in situ	7.7	251	116	1.5	0.07	0.004	41.2	<20	2.48	1.88	4.12	7.6	6.1	23.8	<0.05
SB-3670M	centrifuge	—	—	—	—	—	—	64.5	101	3.48	2.61	4.69	10	94.1	42.5	<0.05
SB-3670M	equilibrated	7.8	561	284	—	—	—	104	<20	5.02	4.29	6.33	11.8	16.3	75.7	<0.05
SB-2400M	in situ	7.7	347	126	1	0.09	0.006	46.6	<20	4.09	3.19	16.2	10.3	12.8	26.4	<0.05
SB-2400M	centrifuge	—	—	—	—	—	—	68.8	213	4.22	6.21	15.4	11.8	197	35.4	<0.05
SB-2400M	equilibrated	7.6	563	172.8	—	—	—	92.1	30	7.19	5.26	15.3	16.5	38.2	60.1	<0.05
SB-1360M	in situ	7.7	218	92	1.6	0.24	0.006	34.6	<20	2.81	1.95	3.78	8.8	15	18.2	<0.05
SB-1360M	centrifuge	—	—	—	—	—	—	52.1	79	3.64	3.16	4.47	10	76.8	29.2	<0.05
SB-1360M	equilibrated	7.4	523	190.4	—	—	—	93.6	<20	7.39	5.7	6.74	16.4	8.5	68.8	<0.05
SB-140M	in situ	7.6	260	107	0.9	0.15	0.004 E	39.9	<20	2.71	2.02	6.03	8.1	11.4	23.4	<0.05
SB-140M	centrifuge	—	—	—	—	—	—	65.8	28	3.65	3.18	5.54	9.4	14	38.9	<0.05
SB-140M	equilibrated	7.4	531	212.4	—	—	—	101	<20	7.31	5.66	9.68	15.8	10.7	69	<0.05
Ompompanoosuc River																
OR-24050M	in situ	7.6	359	150	1.4	1.04	0.006	51.6	<20	7.18	2.99	10.9	9.8	5.4	43.3	<0.05
OR-24050M	centrifuge	—	—	—	—	—	—	68.5	30	7.99	4.05	12.6	10.6	ins	ins	ins
OR-24050M	equilibrated	7.9	709	—	—	—	—	137	<20	12.9	7.78	16.5	16.1	21.5	126	<0.05
OR-23200M	in situ	7.6	277	105	1.4	0.2	0.005	35.8	<20	3.18	1.47	14.9	7.8	12.9	21.6	<0.05
OR-23200M	centrifuge	—	—	—	—	—	—	68.9	23	3.73	3.51	10.6	8.1	38.5	48.2	<0.05
OR-23200M	equilibrated	7.4	535	250.8	—	—	—	86.8	<20	5.46	4.04	16.8	14.5	11.6	77.5	<0.05

Table 5. Constituents in filtered pore waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[The concentrations of the following elements were below their detection limits (given in parentheses in micrograms per liter, µg/L): Ag (<3), As (<1), Hg (<5), and Mo (<2). S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; —, not determined; <, analyte not detected at the reporting level; ins, insufficient sample]

Stream and location	Sample type	Cd (µg/L)	Co (µg/L)	Cr (µg/L)	Cu (µg/L)	Mn (µg/L)	Ni (µg/L)	Pb (µg/L)	Sb (µg/L)	Se (µg/L)	Sr (µg/L)	Tl (µg/L)	U (µg/L)	V (µg/L)	Zn (µg/L)	Cl (mg/L)	SO_4 (mg/L)
Ely Brook																	
EB-1080M	in situ	<0.02	<0.02	<1	2.4	0.3	0.6	0.06	<0.3	<1	46.1	<0.1	< 0.1	<0.5	1.5	1.4	4.4
EB-1080M	centrifuge	1.66	0.46	<1	10.2	45.7	1.4	0.91	<0.3	<1	92.4	<0.1	< 0.1	0.8	29.2	—	—
EB-1080M	equilibrated	0.11	0.55	<1	4.3	2,520	1.7	<0.05	<0.3	1.8	225	<0.1	0.49	<0.5	1.6	3.2	14
EB-770M	in situ	0.28	2.36	<1	27.4	41.1	4.3	0.2	<0.3	<1	51	<0.1	< 0.1	<0.5	25.1	1.4	43
EB-770M	centrifuge	1.25	61.7	<1	43.4	2,780	12.6	<0.05	<0.3	1.2	102	<0.1	< 0.1	<0.5	50	—	—
EB-770M	equilibrated	1.95	71.3	<1	106	5,460	20	<0.05	<0.3	1	195	<0.1	< 0.1	<0.5	114	2.8	175
EB-600M	in situ	0.3	2.37	<1	42.7	14.8	4	<0.05	<0.3	<1	50.4	<0.1	< 0.1	<0.5	31.6	1.4	35
EB-600M	centrifuge	0.34	2.15	<1	108	26.5	3.9	0.08	<0.3	<1	56.2	<0.1	< 0.1	<0.5	24.8	—	—
EB-600M	equilibrated	0.59	8.24	<1	59.6	418	4.5	<0.05	<0.3	<1	71.9	<0.1	< 0.1	<0.5	26	1.5	47
EB-90M	in situ	1.85	57.9	1.4	1,800	501	17.4	1.9	0.77	1.2	63.1	0.1	0.46	<0.5	314	3.4	161
EB-90M	centrifuge	2.87	272	2.1	2,140	2,810	31.1	1.2	<0.3	2.6	82	0.1	0.69	<0.5	514	—	—
EB-90M	equilibrated	2.62	246	1.4	1,700	3,150	39	1.7	<0.3	2.9	113	0.2	1.01	<0.5	616	7	574
Schoolhouse Brook																	
SB-3670M	in situ	<0.02	<0.02	<1	<0.5	0.4	<0.4	0.06	<0.3	<1	191	<0.1	0.26	<0.5	1.9	3.5	6
SB-3670M	centrifuge	0.04	0.12	<1	1	6.8	2.4	0.1	<0.3	<1	274	<0.1	0.42	0.6	3.8	—	—
SB-3670M	equilibrated	0.04	0.68	<1	2.9	3,870	4.1	0.1	0.88	<1	457	0.2	1.07	1	4.4	7	16
SB-2400M	in situ	0.08	0.28	<1	7.9	113	0.5	<0.05	0.53	<1	209	<0.1	0.33	<0.5	3	—	—
SB-2400M	centrifuge	0.15	1.1	<1	16.8	149	2.9	0.1	0.33	1.2	285	<0.1	0.54	<0.5	6.4	—	—
SB-2400M	equilibrated	0.3	2.44	<1	22.8	1,030	2.6	0.05	0.3	1.5	430	0.1	0.72	<0.5	4.9	14	99
SB-1360M	in situ	0.05	0.13	<1	9.6	31.5	0.8	0.2	<0.3	<1	159	<0.1	0.23	<0.5	149	4	17
SB-1360M	centrifuge	0.17	1.59	<1	18.1	171	2.2	0.09	0.44	1.3	224	<0.1	0.37	<0.5	6	—	—
SB-1360M	equilibrated	0.27	4.28	<1	24.9	1,770	2.2	<0.05	<0.3	1.1	436	<0.1	0.62	<0.5	7	6.1	87
SB-140M	in situ	0.04	0.03	<1	5.6	0.6	0.6	0.2	<0.3	<1	168	<0.1	0.2	<0.5	8	7.1	16
SB-140M	centrifuge	0.22	1.05	<1	8.5	209	2.6	0.1	<0.3	<1	272	<0.1	0.4	<0.5	5.3	—	—
SB-140M	equilibrated	0.4	3.81	<1	21.6	1,100	2.2	0.1	<0.3	1	397	<0.1	0.62	<0.5	7.4	7	64
Ompompanoosuc River																	
OR-24050M	in situ	<0.02	0.03	<1	0.56	196	0.4	<0.05	<0.3	<1	228	<0.1	0.4	<0.5	3.8	15	10
OR-24050M	centrifuge	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	—	—
OR-24050M	equilibrated	0.04	0.74	<1	1.6	6,270	3.8	0.09	<0.3	1.2	559	<0.1	1.91	1.8	2.4	15	11
OR-23200M	in situ	0.06	0.47	1.9	4.5	327	0.8	0.3	<0.3	<1	150	<0.1	0.32	<0.5	2.9	15	11
OR-23200M	centrifuge	0.19	3.08	<1	14.2	1,500	2.8	0.09	<0.3	<1	282	<0.1	0.7	1	3.4	—	—
OR-23200M	equilibrated	0.09	2.08	<1	19.1	3,500	2.2	0.2	<0.3	<1	386	<0.1	0.95	<0.5	5.7	12	25

[a] Estimated value, reported concentration is less than the reporting level but greater than the long-term method-detection level.

headwaters of Ely Brook ranged from 7.0 to 7.2, compared to 8.0 to 8.2 for Schoolhouse Brook and the Ompompanoosuc River (fig. 5). Likewise, specific conductance ranged from 51 to 87 microsiemens per centimeter (µS/cm) for the Ely Brook headwaters, and from 196 to 212 µS/cm for the receiving water bodies (fig. 5). Calcium was the dominant dissolved cation (5.8 to 35.7 mg/L), and Mg (1.1 to 1.7 mg/L), Na (1.1 to 5.2 mg/L), and K (1.7 to 2.3 mg/L) occur in subequal proportions. Silica (SiO_2) ranged from 2.2 to 9.1 mg/L and was lowest in pond 1. Alkalinity was the dominant anionic species (19 to 99 mg/L $CaCO_3$ equivalent) (fig. 6). The increased specific conductance of the receiving water bodies was dominantly reflected in higher concentrations of Ca, Mg, Na, and alkalinity compared to the headwaters of Ely Brook. Likewise, hardness values for the head waters (19 to 41 mg/L $CaCO_3$ equivalent) were lower than those for the receiving water bodies (86 to 97 mg/L $CaCO_3$ equivalent) (fig. 6).

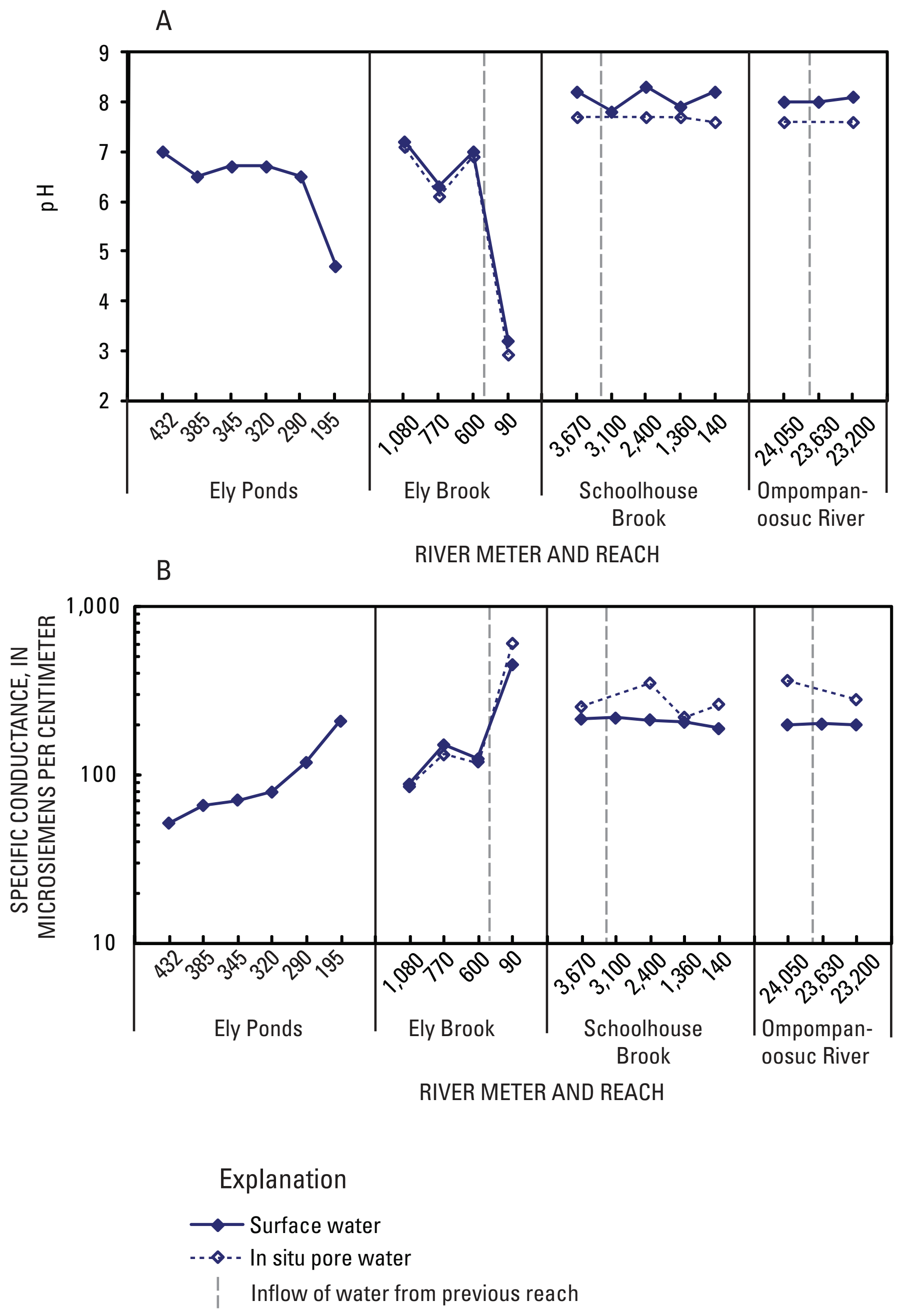


Figure 5. Downstream variations in *(A)* pH and *(B)* specific conductance in surface and in situ pore waters at the Ely Mine Superfund site, Vershire, VT.

Iron, Aluminum, and Manganese

Iron, aluminum, and manganese generally had low concentrations in the background waters at the site (fig. 7). For all background sites, dissolved iron ranged from below the detection limit (<20 µg/L) to just above (66 µg/L). Likewise, dissolved aluminum concentrations ranged from 3.4 to 13.4 µg/L. Dissolved manganese concentrations were slightly higher and ranged from 4.7 to 124 µg/L.

Minor and Trace Inorganic Elements

Minor and trace elements generally have low concentrations in the background waters at the site (fig. 7). Dissolved Ag, As, Cd, Cr, Hg, Sb, and Se concentrations were all below their detection limits. Dissolved Ba concentrations ranged from 18.4 to 20.5 µg/L, dissolved Cu from <0.5 to 1.3 µg/L, dissolved Ni from <0.4 to 0.5 µg/L, dissolved Pb from <0.05 to 0.09 µg/L, and dissolved Zn from 2.3 to 9.3 µg/L. HIs (Cd + Cu + Ni + Pb + Zn) comparing surface-water quality at these sites to hardness-based chronic ambient water-quality standards were all below 1 (0.05–0.82) for these sites.

Dissolved Organic Carbon and Nutrients

Dissolved organic carbon (DOC) concentrations in background waters throughout the study area ranged from 1.2 to 3.5 mg/L, with pond 1 having the highest values. Nutrients were generally low throughout the study area. Total dissolved nitrogen ranged from 0.07 to 0.46 mg/L, and total dissolved phosphorus ranged from 0.002 to 0.036 mg/L.

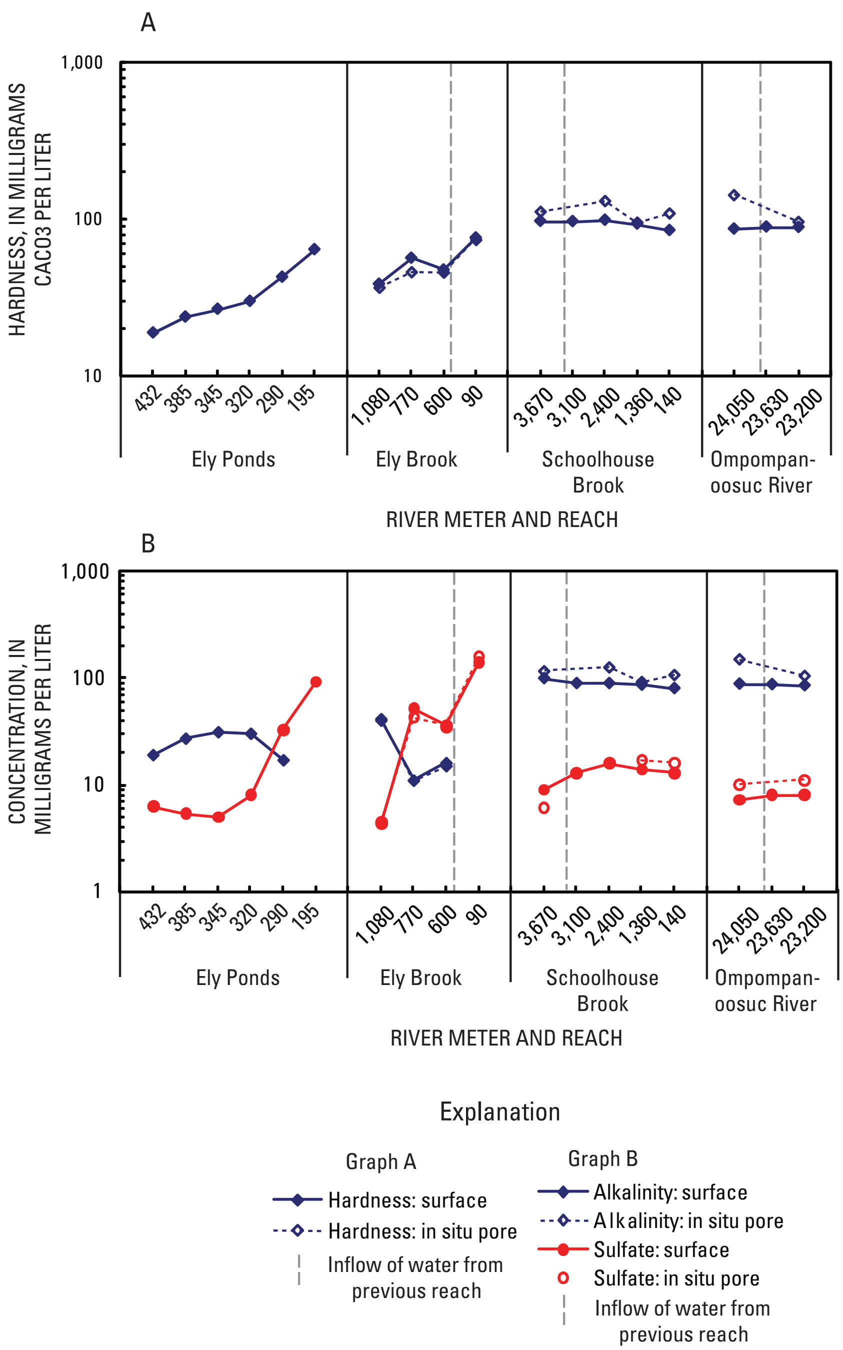


Figure 6. Downstream variations in *(A)* hardness, *(B)* alkalinity and sulfate concentrations in surface and in situ pore waters at the Ely Mine Superfund site, Vershire, VT.

Comparisons with Ambient Water-Quality Criteria

Water-quality data for background reaches are best interpreted in terms of proximity to the Ely Mine site. Ely Brook background conditions were characterized by those locations above the confluence with Ely Brook tributary 4 (river meter 800). Ely Brook tributary 2 background conditions were characterized by those locations above a series of waste-rock piles and seeps (river meter 340). Schoolhouse Brook background conditions were characterized by those locations above the confluence with Ely Brook (river meter 3,270). The Ompompanoosuc River background conditions were characterized by locations above the confluence with Schoolhouse Brook (river meter 23,640). Background concentrations for most elements were less than AWQC with the exception being aluminum, which was greater than AWQC in all background reaches (appendix 5).

Pore-Water Geochemistry

Background pore-water samples were collected from all of the same sites as surface-water samples except for pond 1. These sites include EB-1080M for Ely Brook, SB-3670M for Schoolhouse Brook, and OR-24050M for the Ompompanoosuc River. Minor but significant differences among the chemistry of the three types of pore-water samples were noted. Field parameters and chemical constituents for pore-water samples are summarized in table 5, and complete analyses are reported in appendix 7.

Field Parameters and Major Inorganic Constituents

The pH and specific conductance were measured only on the in situ and equilibrated samples. Collectively, the background pore waters are near neutral with pH ranging from 7.1 to 7.9 (fig. 5). Invariably, the pH of the equilibrated water samples was 0.1 to 0.4 unit higher than the corresponding in situ values. As with the surface water, the specific conductance increased with increasing size of the catchment, going from Ely Brook to Schoolhouse Brook to the Ompompanoosuc River (fig. 5). The values from equilibrated pore waters (389–709 µS/cm) were higher than those from the in situ pore waters (85–359 µS/cm) by roughly 100 to 350 percent.

Calcium was the dominant dissolved cation, and Mg, Na, and K occurred in subequal proportions, similar to the surface-water samples. Invariably, the concentrations of dissolved major cations (Ca: 69.5–137 mg/L; Mg: 6.4–7.8 mg/L; Na: 2.8–16.5 mg/L; K: 4.8–12.9 mg/L) were highest in the equilibrated samples and lowest in the in situ samples (Ca: 12.6–51.6 mg/L; Mg: 1.2–3.0 mg/L; Na: 1.1–10.9 mg/L; K: 1.7–7.2 mg/L). Dissolved silica (SiO_2) concentrations also were highest in the equilibrated samples and lowest in the in situ samples. The concentrations of silica from all sample types ranged from 7.6 to 16.1 mg/L. Alkalinity was the dominant anionic species, and like the major cations, was found in

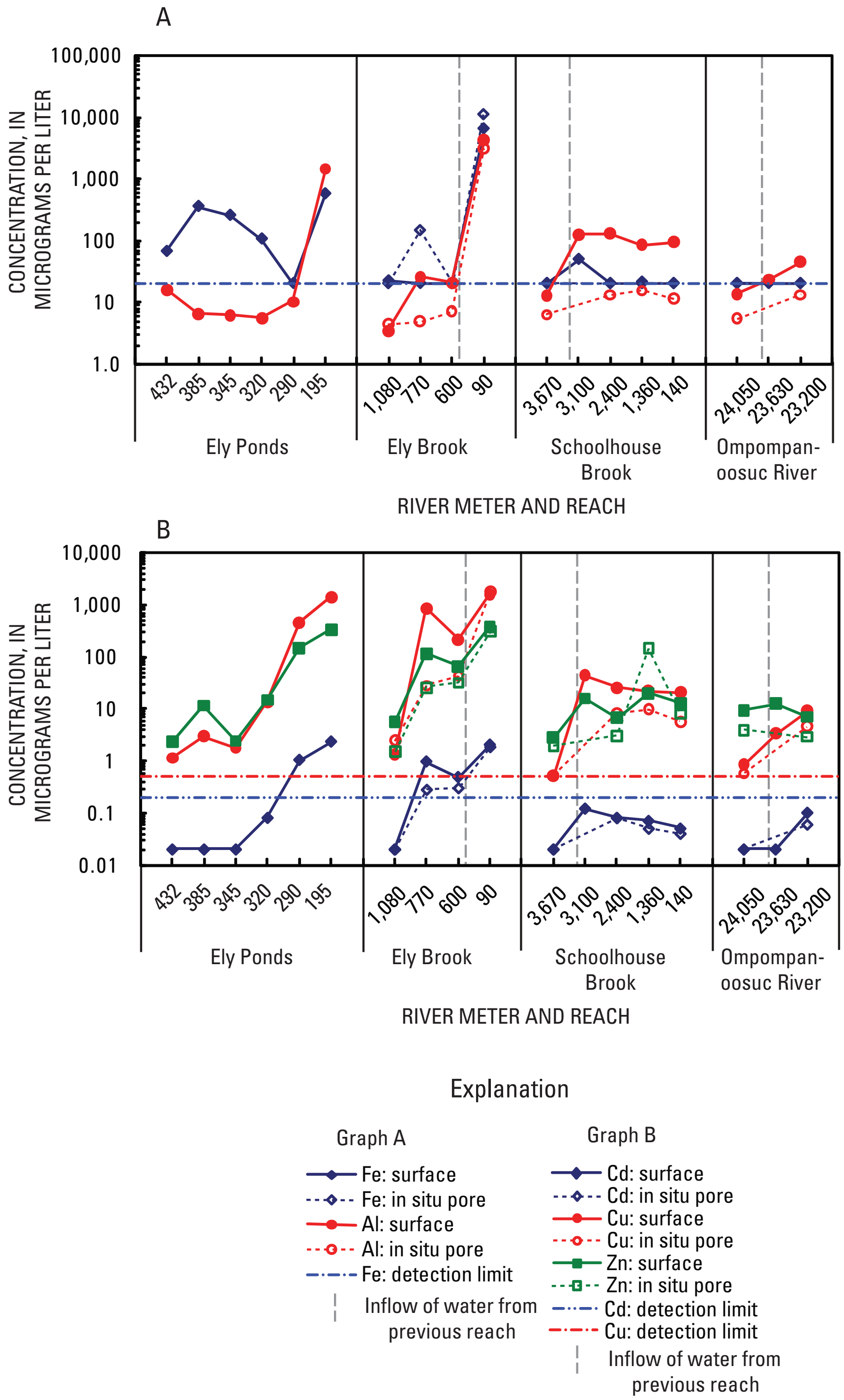


Figure 7. Downstream variations in *(A)* aluminum, iron, *(B)* cadmium, copper, and zinc concentrations in surface and in situ pore waters at the Ely Mine Superfund site, Vershire, VT.

higher concentrations in the equilibrated samples than in the in situ samples (fig. 6). Similarly, the alkalinity concentrations of pore waters increased with increasing drainage area in background sites. The alkalinity values of the in situ pore waters ranged from 40 to 150 mg/L $CaCO_3$ equivalent. Sulfate and chloride occurred in subequal concentrations in pore-water samples and reached maximum concentrations of 10 and 15 mg/L, respectively, in the in situ samples (fig. 6). The hardness values of the pore waters followed identical trends. The hardness values increased with catchment area (fig. 6). Invariably, the in situ samples had the lowest values (36.3 to 141.3 mg/L $CaCO_3$ equivalent), and the 28-day equilibrated samples had the highest (200.1 to 374.4 mg/L $CaCO_3$ equivalent).

Iron, Aluminum, and Manganese

Iron, aluminum, and manganese generally had low concentrations in the background pore waters at the site (fig. 7). For all background sites, dissolved iron was below the detection limit (<20 µg/L) for the in situ and equilibrated splits but ranged from 30 to 436 µg/L in the centrifuged splits with the highest concentrations occurring in the Ely Brook headwaters and the lowest in the Ompompanoosuc River headwaters. Dissolved aluminum concentrations ranged from 4.3 to 94.1 µg/L with the highest concentrations in the centrifuged splits. Dissolved manganese concentrations were slightly higher and ranged from 0.3 to 6,270 µg/L with concentrations increasing with catchment area. The in situ samples had the lowest concentrations, and the equilibrated samples had the highest, up to two orders of magnitude higher.

Minor and Trace Inorganic Elements

Minor and trace elements generally had low concentrations in the background pore waters at the site (fig. 7). Dissolved Ag, As, Cr, and Hg concentrations were all below their detection limits. Dissolved Ba concentrations ranged from 16.6 to 126 µg/L, dissolved Cd from <0.02 to 1.7 µg/L, dissolved Cu from <0.5 to 10.2 µg/L, dissolved Ni from <0.4 to 4.1 µg/L, dissolved Pb from <0.05 to 0.9 µg/L, dissolved Sb from <0.3 to 0.9 µg/L, dissolved Se from <1 to 1.8 µg/L, and dissolved Zn from 1.5 to 29.2 µg/L. HIs for background pore-water samples were all below 1 (0.00–0.91) with the exception of the centrifuged split for EB-1080M, which had an index of 9.6 due to elevated concentrations of copper and especially cadmium.

Dissolved Organic Carbon and Nutrients

DOC and nutrient concentrations were determined only on samples of in situ pore water. DOC concentrations throughout the study area ranged from 1.4 to 1.6 mg/L. Nutrients were generally low throughout the study area. Total dissolved nitrogen ranged from 0.07 to 1.04 mg/L, and total dissolved phosphorus ranged from 0.003 to 0.006 mg/L with the Ompompanoosuc River having the highest concentrations.

Comparisons with Ambient Water-Quality Criteria

Background concentrations for most elements in pore waters were less than AWQC with the exception being aluminum, cadmium, and copper (appendix 7). Concentrations of these elements exceeded AWQC only locally for the centrifuged pore-water samples. Concentrations of aluminum in the centrifuged background pore-water samples from Ely Brook and Schoolhouse Brook exceeded the chronic AWQC. Concentrations of cadmium in the centrifuged background pore-waters samples from Ely Brook exceeded both the acute and chronic AWQC. Concentrations of copper in the centrifuged background pore-water samples from Ely Brook exceeded only the chronic AWQC.

Sediment Geochemistry

The major-element geochemistry of background sediments reflects their siliciclastic constituents. Chemical constituents for sediment samples are summarized in table 6, and complete analyses are reported in appendix 8. SEM-AVS data for sediment samples are summarized in table 7, and complete analyses are reported in appendix 4. Aluminum ranged from 3.1 to 4.3 weight percent in the background streams and was 6.7 weight percent in pond 1. The higher concentration of aluminum in the pond probably reflected a higher proportion of clays compared to the higher energy stream settings. Na, K, Ca, and Mg all ranged from 0.7 to 1.9 weight percent. Iron ranged from 1.4 to 2.8 weight percent in the stream sediments, and reached 4.4 weight percent in the pond 1 sediments. Carbonate carbon was low, between 0.01 and 0.20 weight percent carbon, whereas total organic carbon in the stream sediments ranged from 0.32 to 0.37 weight percent, and was 8.0 weight percent in pond 1.

Table 6. Select chemistry results for sediments collected in August and September 2006 from the Ely Mine study area, Vershire, VT.

[wt. %, weight percent; mg/kg, milligrams per kilogram; —, not determined; <, analyte not detected at the reporting level]

Stream and location	Total C (wt. % as C)	CO_2 (wt. % as C)	Carbonate (wt. % as C)	Total organic C (wt. % as C)	Al (wt. %)	Ca (wt. %)	Fe (wt. %)	K (wt. %)	Mg (wt. %)	Na (wt. %)	S (wt. %)	Ag (mg/kg)	As (mg/kg)	Ba (mg/kg)	Cd (mg/kg)
PEC[a]	—	—	—	—	—	—	—	—	—	—	—	—	33	—	4.98
Ely Brook															
EB-1080M	0.35	0.04	0.01	0.34	4.26	1.05	2.76	1.03	0.98	1	0.04	<1	<1	249	0.1
EB-770M	0.55	0.07	0.02	0.53	4.81	1.24	5.5	1.06	1.01	1.06	0.3	<1	2	255	0.4
EB-600M	0.25	0.09	0.02	0.23	4.66	1.25	7.09	1.05	1.05	1.05	0.41	<1	3	236	1
EB-90M	0.28	0.06	0.02	0.26	3.98	1.13	16.7	0.95	0.76	1.06	1.7	3	2	166	1
EB-90M-OBS (overbank sed.)	2.46	0.15	0.04	2.42	3.21	0.31	36.3	2.45	0.7	0.56	4.66	17	4	360	0.2
EB-20M	0.55	0.08	0.02	0.53	4.12	1.08	14.6	1.03	0.73	1.19	1.41	3	2	191	0.7
Ely Ponds															
EM-POND1	8.04	0.16	0.04	8	6.68	1.93	4.39	0.89	1.56	1.78	0.42	<1	<1	276	0.8
EM-POND2	9.36	0.23	0.06	9.3	6.12	1.89	4.48	1.09	1.38	1.3	0.54	<1	<1	321	1.3
EM-POND3	10.4	0.26	0.07	10.33	5.49	1.47	5.84	0.84	1.22	0.91	0.37	<1	3	377	1.2
EM-POND4	10.1	0.18	0.05	10.05	5.63	1.11	3.88	1.11	1.25	0.69	0.34	<1	7	337	2.5
EM-POND5	9.57	0.26	0.07	9.5	6.45	0.92	4.99	0.79	1.02	0.89	0.71	<1	3	296	4
EM-POND6	6.54	0.27	0.07	6.47	11.1	0.67	3.5	0.75	0.73	0.65	0.93	<1	3	184	0.2
Schoolhouse Brook															
SB-3670M	0.52	0.75	0.2	0.32	3.1	1.42	1.39	0.81	0.66	0.68	0.03	<1	3	207	<0.1
SB-3260M	0.39	0.48	0.13	0.26	3.56	1.43	5.88	0.82	0.62	0.8	0.42	<1	2	173	0.3
SB-2400M	0.41	0.69	0.19	0.22	3.61	1.34	2.03	0.86	0.63	0.76	0.08	<1	1	191	0.1
SB-1360M	0.4	0.56	0.15	0.25	3.48	1.62	2.78	0.85	0.67	0.79	0.1	<1	1	191	0.2
SB-140M	0.34	0.35	0.1	0.24	3.69	1.3	2.63	0.92	0.62	0.79	0.08	<1	1	198	0.2
Ompompanoosuc River															
OR-24050M	0.41	0.15	0.04	0.37	3.27	1.13	1.4	0.8	0.73	0.72	0.02	<1	3	187	<0.1
OR-23200M	0.3	0.17	0.05	0.25	3.54	1.3	2.28	0.84	0.71	0.76	0.03	<1	5	195	0.1

The concentrations of most trace elements were low, with the exception of Cr, Cu, and Ni. Maximum concentrations in the background stream and pond sediments were 3 milligrams per kilogram (mg/kg) for As, 0.07 mg/kg for Hg, 0.8 mg/kg for Cd, 102 mg/kg for Cr, 86.6 mg/kg for Cu, 35.6 mg/kg for Ni, 26.4 mg/kg for Pb, 0.7 mg/kg for Se, and 126 mg/kg for Zn.

Acid volatile sulfide for the stream-sediment samples for background sites was below the detection limit of 23 mg/kg (0.7 micromoles per gram, µmol/g) for all background stream sediments. The sum of the concentrations of simultaneously extracted metals (Cd + Cu + Pb + Ni + Zn) was low, ranging from 0.2 to 0.5 µmol/g with the Ely Brook site being the highest and the Ompompanoosuc River site being the lowest. Simultaneously extracted mercury was below the detection limit (0.2 mg/kg; 0.001 µmol/g).

PEC values are available for As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn. In all cases for the background sites, including pond 1, the concentrations of these elements were below these limits. HIs for these elements in sediments were above 1 at sites EB-1080M (1.1) and pond 1 (2), but below 1 at sites SB-3670M (0.6) and OR-24050M (0.4). The (ΣSEM-AVS)/f_{OC} values for all background stream-sediment samples ranged from –160 to –60 µmol/gOC, which were well within the no-effects range, and well below the onset of uncertain effects at 150 µmol/gOC (USEPA, 2005).

Bioassay Results

Toxicity testing of sediments was done only on samples from the stream reaches. Tests were conducted using *Hyalella azteca* for 28-day exposures and *Chironomus dilutus* for 12-day exposures. For both organisms, both survival and growth endpoints were measured (table 8). For reference sites EB-1080M, SB-3670M, and OR-24050M, *H. azteca* had acceptable survival at 93.8 ± 1.8, 93.8 ± 4.6, and 93.8 ± 6.5 percent, respectively, during the 28-day tests. Growth in the reference organisms was 3.24 ± 0.05 mm for EB-1080M,

Table 6. Select chemistry results for sediments collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[wt. %, weight percent; mg/kg, milligrams per kilogram; —, not determined; <, analyte not detected at the reporting level]

Stream and location	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Hg (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Sb (mg/kg)	Se (mg/kg)	Sr (mg/kg)	Tl (mg/kg)	U (mg/kg)	V (mg/kg)	Zn (mg/kg)
PEC[a]	—	111	149	1.06	—	—	48.6	128	—	—	—	—	—	—	459
Ely Brook															
EB-1080M	9.8	57	75.4	<0.02[a]	780	0.41	16.5	24.8	<0.05	0.3	133	0.3	0.9	73	56
EB-770M	22.4	66	1160	<0.02	2,090	2.11	20	14.6	0.06	4.1	111	0.3	1.4	96	122
EB-600M	65.5	64	2730	<0.02	1,820	8.33	23.4	174	1.15	8.1	99	0.3	1.6	97	186
EB-90M	14.4	62	5950	<0.02	2,200	17.4	10.6	38.1	2.03	30.1	73.1	0.3	0.7	112	206
EB-90M-OBS (overbank sed.)	13.3	89	1440	0.13	429	44.5	19.9	78.6	0.53	71.1	55.3	1.3	0.9	154	147
EB-20M	15.1	67	3,700	0.03	1,020	16.2	15	38	1.15	35.2	92.2	0.3	0.8	112	196
Ely Ponds															
EM-POND1	19.8	102	86.6	0.07	527	0.63	35.6	26.4	<0.05	0.7	172	0.4	2.3	163	126
EM-POND2	24	130	87.6	0.11	769	2.58	45.4	31.8	0.11	1.1	165	0.6	3.5	148	131
EM-POND3	30.9	85	81.7	0.15	3,130	2.15	38.6	43.7	0.3	1.4	134	0.8	3.5	125	127
EM-POND4	29.2	67	380	0.09	2,410	1.75	61.1	20.2	0.31	0.7	91.9	0.5	3.1	93	316
EM-POND5	78.3	70	3,540	0.09	1,430	2.54	56.8	23.5	0.97	1.3	76.5	0.5	5.7	79	507
EM-POND6	13.3	47	1,770	0.07	443	2.8	29.5	18.4	1.42	1.4	94.2	0.2	6.2	68	68
Schoolhouse Brook															
SB-3670M	4.8	24	10.4	<0.02	501	0.28	13.2	11.2	0.15	<0.2	202	0.2	0.8	40	32
SB-3260M	11	40	1,390	<0.02	1,120	7.26	11.5	17.9	2.39	9.8	164	0.2	1	62	93
SB-2400M	10.8	23	167	<0.02	504	2.29	11.4	10.5	0.65	1.8	193	0.2	0.8	43	54
SB-1360M	9.6	28	198	<0.02	864	2.53	11.6	11	1.8	1.5	206	0.2	0.8	48	66
SB-140M	13.5	32	243	<0.02	869	2.59	13.6	31.4	2.14	1.1	188	0.2	0.9	52	85
Ompompanoosuc River															
OR-24050M	4.5	37	4.5	<0.02	475	0.16	11.7	9.6	0.19	<0.2	198	0.2	0.7	38	33
OR-23200M	8.1	29	76.7	<0.02	1,120	0.5	10.8	10.4	0.22	0.3	193	0.2	0.8	49	53

[a] Probable effects concentration (MacDonald and others, 2000).

Table 7. Acid volatile sulfide (AVS) and simultaneously extractable metals (SEM) results for stream sediments from the Ely Mine study area, Vershire, VT.

[%, percent; mg/kg, milligrams per kilogram; µmol/g, micromoles per gram]

Stream and location	Solids[a] (%)	ASS[b] (mg/kg)	AVS[c] (µmol/g)	SEM[d] Cd (µmol/g)	Cu (µmol/g)	Fe (µmol/g)	Pb (µmol/g)	Mn (µmol/g)	Ni (µmol/g)	Zn (µmol/g)	Hg (µmol/g)	SEM/AVS[e]
Ely Brook												
EB-1080M	72.3	<10.9[f]	<0.67	<0.0012	0.2	53.4	0.013	4.1	0.048	0.2	<0.0009	0
EB-770M	76.5	<10.5	<0.64	0.0012	5.4	48.3	0.011	2.1	0.036	0.3	<0.0008	0
EB-600M	79.4	<10.1	<0.61	0.0036	13.8	39.4	0.017	4.8	0.055	0.65	<0.00075	0
EB-90M	75.7	<10.2	<0.63	<0.0012	1.1	124.4	0.019	0.1	0.013	0.052	<0.0008	0
Schoolhouse Brook												
SB-3670M	68.8	<11.6	<0.71	<0.0012	0.024	33.3	0.013	3.6	0.039	0.12	<0.0009	0
SB-2400M	77.9	<10.3	<0.64	<0.0012	0.99	39.8	0.0092	2.8	0.037	0.3	<0.0008	0
SB-1360M	74.9	<10.3	<0.65	<0.0012	1.0	35.8	0.0087	3.2	0.044	0.3	<0.0008	0
SB-140M	73.5	<10.8	<0.66	<0.0012	1.2	38.0	0.016	2.9	0.043	0.35	<0.00085	0
Ompompanoosuc River												
OR-24050M	72.8	<10.9	<0.69	<0.0012	0.017	25.6	0.014	2.4	0.036	0.11	<0.00085	0
OR-23200M	69.7	<11.5	<0.68	<0.0012	0.27	19.2	0.0068	1.9	0.026	0.14	<0.0009	0

[a] Solids determined by Method IN623.

[b] Acid soluble sulfide (total sulfide) detemined by SW846 Method 9030B/9034.

[c] Acid volatile sulfide determined by SW846 Method 6010B.

[d] Simultaneously extracteable metals detemined by SW846 Method 6010B(ICP-AES) for all metals except Hg, which was determined by Method 7471A (cold-vapor atomic absorption).

[e] SEM/AVS is the sum of the concentrations of all metals divided by AVS, which in this study was less than the detection limit.

[f] <: analyte was analyzed for but not detected above reporting limit.

Table 8. Results of 28-day toxicity tests with the amphipod *Hyalella azteca* and of 10-day toxicity tests with the midge *Chironomus dilutus* exposed to sediments from Ely Mine site, fall 2006.

[%, percent; mm, millimeters; mg, milligrams; mean, mean value of eight replicates per sediment; std. err., standard error]

Stream and location	Amphipod, *Hyalella azteca* (28-day test) Survival (%) Mean	Std. err.	Total length (mm) Mean	Std. err.	Midge, *Chironomus dilutus* (10-day test) Survival (%) Mean	Std. err.	Ash-free dry wt. (mg) Mean	Std. err.
Control								
FL (C)[a]	96.3	1.8	3.23	0.08	86.3	4.2	1.30	0.10
Ely Brook								
EB-1080M (R)[b]	93.8	1.8	3.24	0.05	63.8	6.5	1.21	0.11
EB-770M	68.8	5.8	2.45	0.06	61.3	4.8	0.61	0.11
EB-600M	6.3	2.6	1.96	0.11	65.0	6.0	0.28	0.01
EB-90M	91.3	4.0	3.39	0.06	72.5	4.5	1.73	0.37
Schoolhouse Brook								
SB-3670M (R)	93.8	4.6	3.31	0.06	76.3	5.3	1.00	0.05
SB-2400M	52.5	7.5	2.43	0.11	80.0	4.2	0.78	0.04
SB-1360M	64.3	6.1	2.53	0.11	62.5	5.9	1.28	0.08
SB-140M	52.5	9.4	2.55	0.13	67.5	3.7	0.81	0.05
SB-140M (D)[c]	68.8	4.4	2.48	0.12	83.8	4.6	0.59	0.05
Ompompanoosuc River								
OR-24050M (R)	93.8	6.5	3.21	0.02	90.0	1.9	1.06	0.08
OR-23200M	91.3	3.0	3.17	0.07	83.8	6.0	0.96	0.14

[a] C, indicates laboratory control sediment.

[b] R, indicates local reference sites.

[c] D, indicates lab duplicate.

was 3.31 ± 0.06 mm for SB-3670M, and was 3.21 ± 0.02 mm for OR-24050M. In contrast, survival for *C. dilutus* was lower in EB-1080M (63.8 ± 6.5 percent), SB-3670M (76.3 ± 5.3 percent), and OR-24050M (90.0 ± 1.9 percent). Growth, on an ash-free dry-weight basis, was 1.21 ± 0.11 mg for EB-1080M, 1.00 ± 0.05 mg for SB-3670M, and 1.06 ± 0.08 mg for OR-24050M.

Ecological Indicators

An evaluation of ecological indicators used to assess the relative ecosystem health across the sites indicated that background surface-water sites had well-established aquatic communities (figs. 8–10 and table 9). RTH invertebrate data for site EB-1080M reflected a good ecological structure and function. Invertebrate richness at site EB-1080M was 43 taxa, and abundance was 1,756 individuals. Depositional-targeted habitat (DTH) invertebrate data also reflected a good ecological structure and function. Invertebrate richness at site EB-1080M was 34 taxa, and abundance was 415 individuals. QMH invertebrate data for pond 1 also reflected a good ecological structure and function. Invertebrate richness at pond 1 was 59 taxa. Invertebrate abundance was high in pond 1 (1,950 individuals).

At the Schoolhouse Brook reference site (SB-3670M), RTH inverterbrate data reflected a good ecological structure and function. Invertebrate richness at site SB-3670M was 56 taxa, and abundance was 3,900 individuals. DTH invertebrate data also reflected a good ecological structure and function. Invertebrate richness at site SB-3670M was 30 taxa, and abundance was 161 individuals. The index of biotic integrity for fish was 42. Likewise, at the Ompompanoosuc River reference site (OR-24050M), RTH invertebrate data reflected a good ecological structure and function. Invertebrate richness at site OR-24050M was 84 taxa, and abundance was 2,864 individuals. DTH invertebrate data also reflected a good ecological structure and function. Invertebrate richness at site OR-24050M was 21 taxa, and abundance was 160 individuals. The index of biotic integrity for fish was 33.

Ely Brook Tributaries

Surface-Water Geochemistry

Four tributaries flow into Ely Brook from the east and come in contact with mine waste or drain mine shafts directly (fig. 2). Each of the tributaries was analyzed individually to determine if there were significant differences in water chemistry based on previously published data (Argue and others, 2008). For this analysis, seep 13 was grouped with locations on tributary 1, seeps 6, 7, 10, 11, and 14 were grouped with locations on tributary 2, seeps 2–5, 8, 9, 15–18, 20, and 21 were grouped with locations on tributary 3, and seeps 1, 12, and 19 were grouped with locations on tributary 4. Tributary 2 includes a series of ponds (ponds 1–6), which are the focus of this study and the focus of amphibian studies in the baseline ecological risk assessment (TechLaw, Inc., 2008). Chemical constituents for surface-water samples are summarized in table 4, and complete analyses are reported in appendix 6.

Field Parameters and Major Inorganic Constituents

In general, the gross chemical properties of the tributary 2 pond-water samples display systematic degradation moving downstream from pond 1, the reference site, through ponds 2 through 5. The pH of tributary 2 dropped from 7.0

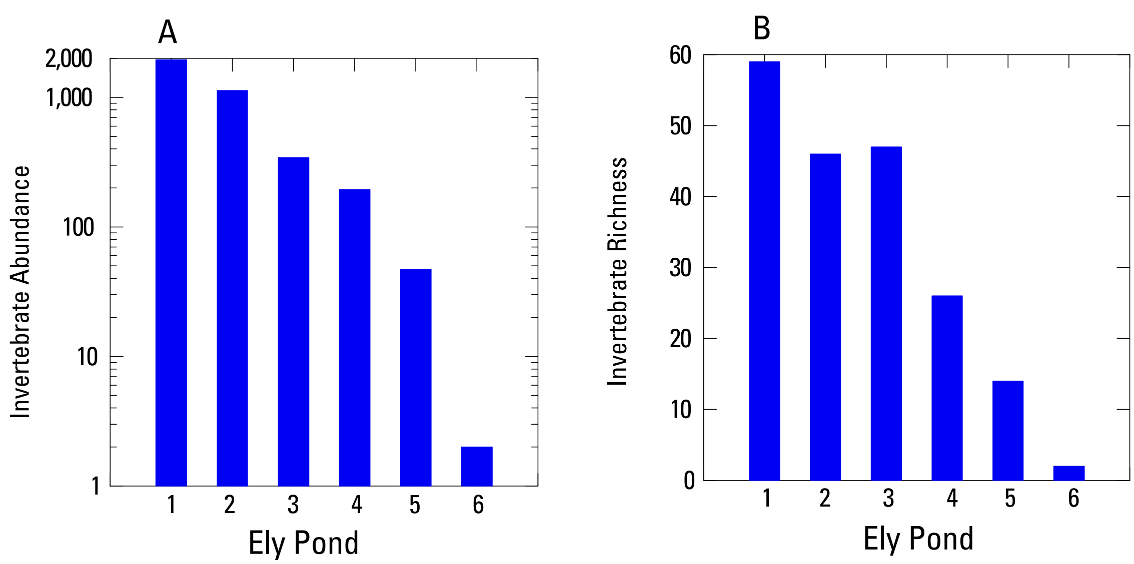


Figure 8. Qualitative multi-habitat (QMH) invertebrate *(A)* abundance and *(B)* richness values among the Ely ponds, Vershire, VT. Pond 1 was farthest upgradient from sources of contamination and was used to represent background conditions. Locations are situated in the frames from up- to downgradient.

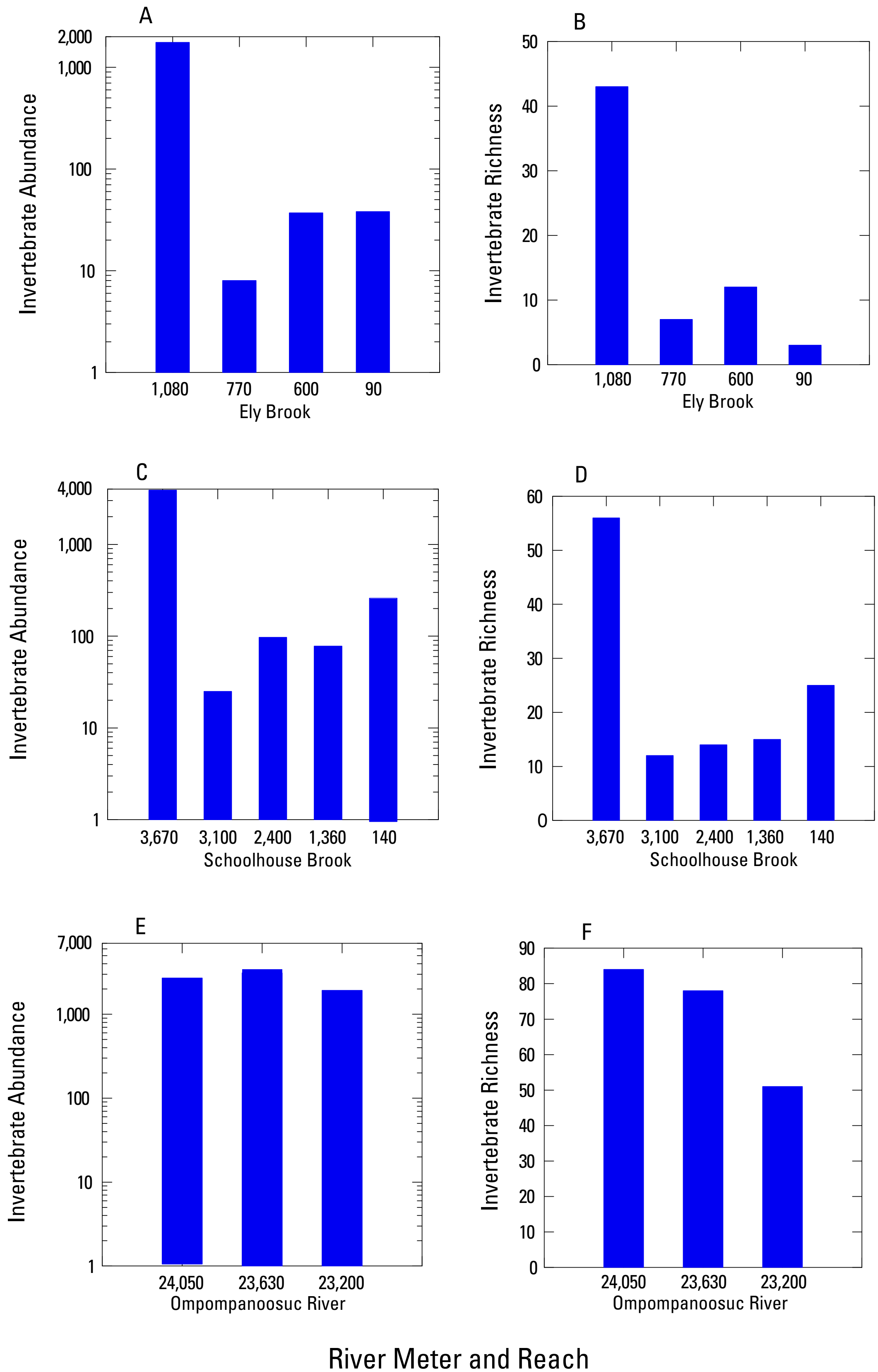


Figure 9. Riffle-targeted habitat (RTH) invertebrate *(A)* abundance and *(B)* richness values in Ely Brook, *(C)* abundance and *(D)* richness values in Schoolhouse Brook, and *(E)* abundance and *(F)* richness values in the Ompompanoosuc River. The first location in each of the frames was farthest upgradient from sources of contamination and was used to represent background conditions for the stream.

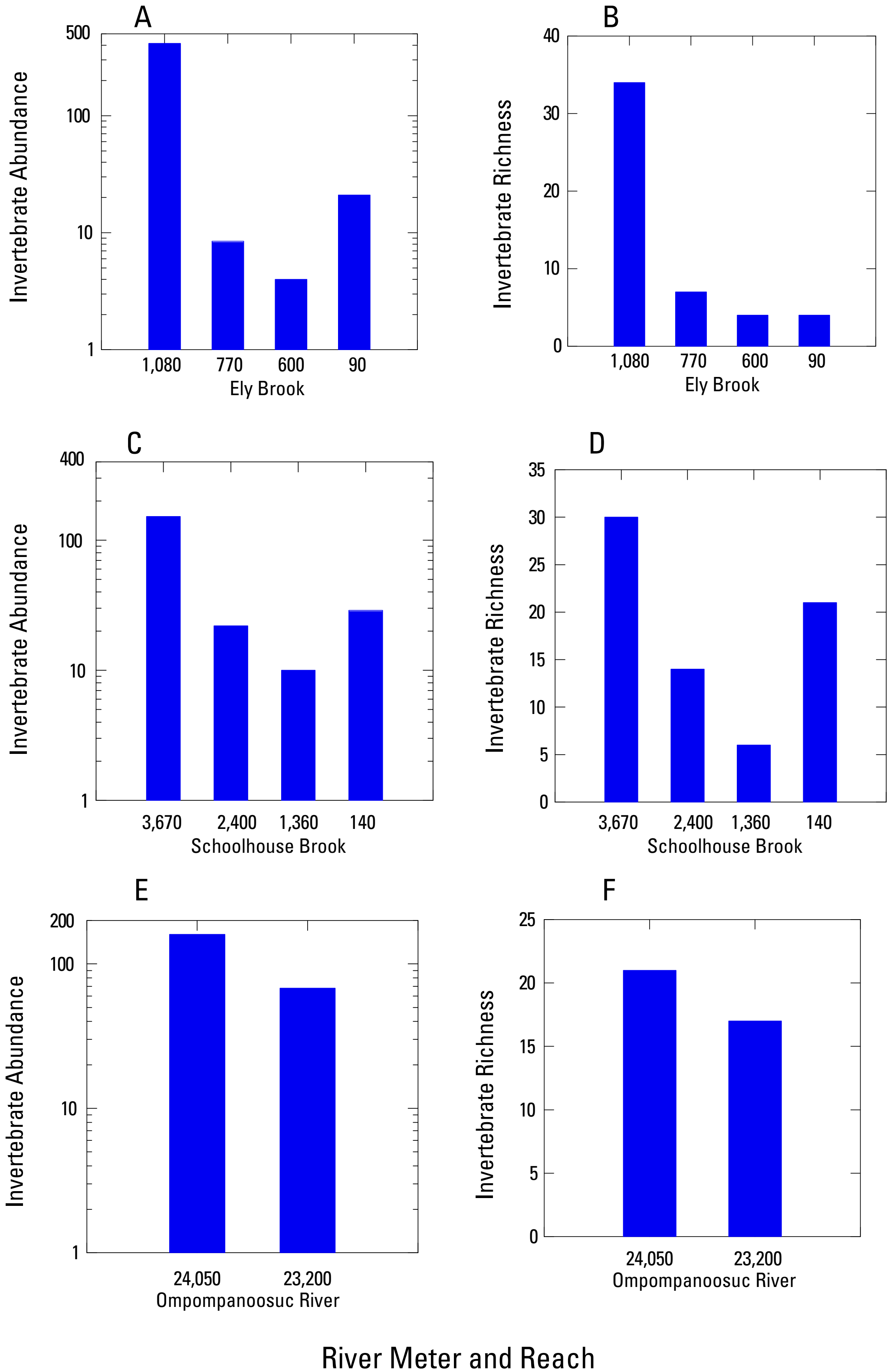


Figure 10. Depositional-targeted habitat (DTH) invertebrate *(A)* abundance and *(B)* richness values in Ely Brook, *(C)* abundance and *(D)* richness values in Schoolhouse Brook, and *(E)* abundance and *(F)* richness values in the Ompompanoosuc River. The first location in each of the frames was farthest upgradient from sources of contamination and was used to represent background conditions for the stream.

Table 9. Summary of selected invertebrate and fish data and the hazard index used for comparison of assemblage data to water quality at sampling locations in the Ely Mine study area, Vershire, VT. Refer to table 1 and figure 1 for site names, station numbers, and locations.

[RTH, riffle-targeted habitat; DTH, depositional-targeted habitat; QMH, qualitative multi-habitat; IBI, index of biotic integrity; SW, surface water; PW, pore water]

Stream and location	Invertebrate assemblage metrics						Fish assemblage IBI[a]	Hazard index[b]	
	RTH		DTH		QMH			SW	PW
	Abundance	Richness	Abundance	Richness	Abundance	Richness			
Ely Brook									
EB-1080M	1,756	43	415	34				0.5	0.6
EB-770M	8	7	8	7				144.0	6.8
EB-600M	37	12	4	4				76.4	9.7
EB-90M	38	3	21	4				199.3	270.3
Ely Ponds									
Ely Pond 1					1,950	59		.9	
Ely Pond 2					1,128	46		1.6	
Ely Pond 3					342	47		.7	
Ely Pond 4					194	26		4.0	
Ely Pond 5					47	14		92.0	
Ely Pond 6					2	2		240.0	
Schoolhouse Brook									
SB-3670M	3,900	56	161	30			42	.0	<0.5
SB-3100M	25	12					9	3.9	
SB-2400M	97	14	22	14			9	2.4	.7
SB-1360M	78	15	10	6			18	2.3	2.7
SB-140M	278	25	29	21			29	2.4	.7
Ompompanoosuc River									
OR-24050M	2,864	84	160	21			33	.2	.0
OR-23630M	3,124	78					33	.4	
OR-23200M	1,924	51	68	17			33	1.2	.6

[a] Index of biotic integrity values were compiled by the Vermont Department of Environmental Conservation (2008).

[b] The hazard index for surface water was compared with RTH and QMH metrics and fish index of biotic integrity values; the hazard index for pore water was compared with DTH metrics.

in the reference pond to 6.5 in pond 5; pond 6 had a pH of 4.7 (fig. 5). The specific conductance concomitantly increased from 51 µS/cm in the reference pond to 117 µS/cm in pond 5; the specific conductance of pond 6 was 206 µS/cm (fig. 5). Calcium was the dominant dissolved cation and increased from 5.8 to 18.6 mg/L. Magnesium (1.1 to 4.2 mg/L), Na (1.2 to 1.6 mg/L), and K (1.7 to 2.5 mg/L) occurred in subequal proportions and were lowest in the reference site. Silica (SiO_2) ranged from 2.2 to 14.8 mg/L and likewise was lowest in the reference pond. Alkalinity was the dominant anionic species (19 to 30 mg/L $CaCO_3$ equivalent) in ponds 1 through 4, but sulfate was dominant in ponds 5 and 6, which undoubtedly reflects increasing contributions of acid-mine drainage (fig. 6). Hardness values increased from 18.8 mg/L $CaCO_3$ equivalent in the reference pond to 42.5 mg/L $CaCO_3$ equivalent in pond 5 (fig. 6).

Iron, Aluminum, and Manganese

Iron, aluminum, and manganese showed crude increases from the reference pond moving downstream (fig. 7). Dissolved iron increased from 66 µg/L to 565 µg/L in pond 6, although the concentration in pond 5 was below detection (<20 µg/L). Dissolved aluminum concentrations were 15.8 µg/L in the reference pond and 1,410 µg/L in pond 6 with values ranging between 5.5 and 10.1 µg/L between these two ponds. Dissolved manganese concentrations increased from 2.7 µg/L in the reference pond to 564 µg/L in pond 6.

Minor and Trace Inorganic Elements

The dissolved concentrations of the minor and trace elements that typify the Ely Mine deposit (Cd, Co, Cu, Ni, and Zn) generally increased moving downstream through the ponds (fig. 7). The concentrations of all other minor and trace elements tended to be low, near their respective detection limits. Dissolved Ag, As, Cr, Se, Tl, and V concentrations were all below their detection limits. Dissolved Ba concentrations ranged from 9.6 to 18.6 µg/L, dissolved Be from <0.05 to 0.2 µg/L, dissolved Pb from <0.05 to 0.4 µg/L, dissolved Sb from <0.3 to 0.62 µg/L, dissolved Sr from 20.5 to 50.4 µg/L, and dissolved U from <0.1 to 0.2 µg/L.

The metals associated with the deposit have distinctly higher dissolved concentrations in the ponds. Dissolved Cd concentrations ranged from <0.02 to 2.28 µg/L, dissolved Co from 0.03 to 46.3 µg/L, dissolved Cu from 1.1 to 1,380 µg/L, dissolved Ni from <0.4 to 16.7 µg/L, and dissolved Zn from 2.3 to 325 µg/L. HIs (Cd + Cu + Ni + Pb + Zn) comparing surface-water quality at these sites to hardness-based chronic ambient water-quality standards ranged from 0.82 in the reference pond up to 244 in pond 6 (table 10). HIs generally increased moving downstream and indicate significant potential for impairment in ponds 5 and 6, and possibly 4.

Dissolved Organic Carbon and Nutrients

DOC concentrations throughout the study area ranged from 1.1 to 3.5 mg/L with Ely pond 1 having the highest values. Nutrients were generally low throughout the study area. Total dissolved nitrogen ranged from 0.10 to 0.46 mg/L, and total dissolved phosphorus ranged from 0.003 to 0.036 mg/L.

Comparisons with Ambient Water-Quality Criteria and Relations among Reaches

The four tributaries that flow into Ely Brook from the east all come in contact with mine waste or drain mine shafts directly (fig. 2). Concentrations of elements greater than AWQC were observed in tributary 1 for Al, Ba, Cd, Co, Cu, Mn, and Zn; in tributary 2 for Al, Ba, Cd, Cr, Co, Cu, Fe, Mn, Ni, U, and Zn; in tributary 3 for Al, Ba, Cd, Cr, Co, Cu, Fe, Pb, Mn, Se, U, and Zn; and in tributary 4 for Al, Ba, Cd, Cr, Co, Cu, Fe, Mn, Ni, Se, U, and Zn (fig. 11, appendix 2). Median concentrations of most elements in surface waters of tributary 1 were similar to or less than background conditions with the exception of copper, which was higher (fig. 11).

Table 10. Summary of the hazard quotient and hazard index for select constituents in waters and stream sediments at sampling locations in the Ely Mine study area, Vershire, VT, August 21 to 23, 2006. Refer to table 1 and figure 1 for site names, station numbers, and locations.

[SW, surface water; PW, in situ pore water; SED, sediment; —, not determined because analyte concentration is below the reporting level]

Stream and location	Hazard quotient															Hazard index		
	Cadmium			Copper			Nickel			Lead			Zinc					
	SW	PW	SED	SW	PW	SED	SW	PW	SED	SW	PW	SED	SW	PW	SED	SW	PW	SED
Ely Brook																		
EB-1080M	—	—	0.0	0.3	0.6	0.5	0.0	0.0	0.3	—	0.1	0.2	0.1	0.6	0.1	0.4	1.3	1.1
EB-770M	5.8	2.0	0.1	153	6.0	7.8	0.4	0.2	0.4	0.07	0.2	0.1	1.6	0.8	0.3	161	9.2	8.7
EB-600M	3.3	2.1	0.2	45	9.4	18	0.2	0.2	0.5	0.05	—	1.4	1.0	0.4	0.4	50	12	21
EB-90M	9.8	9.3	0.2	222	262.2	40	0.5	0.4	0.2	0.51	1.1	0.3	4.0	5.7	0.4	237	279	41
Ely Ponds																		
Ely Pond 1	—		0.2	0.5		0.6	—		0.7	0.23		0.2	0.1		0.3	0.8		2
Ely Pond 2	—		0.3	1.1		0.6	0.0		0.9	0.16		0.2	0.3		0.3	1.6		2.3
Ely Pond 3	—		0.2	0.6		0.5	0.0		0.8	0.17		0.3	0.1		0.3	0.9		2.1
Ely Pond 4	0.8		0.5	4.2		2.6	0.1		1.3	0.15		0.2	0.3		0.7	5.6		5.3
Ely Pond 5	7.5		0.8	103		24	0.3		1.2	—		0.2	2.5		1.1	113		27
Ely Pond 6	12.7		0.0	227		12	0.5		0.6	0.26		0.1	4.0		0.1	244		13
Schoolhouse Brook																		
SB-3670M	—	—	—	—	—	0.1	—	—	0.3	0.02	0.0	0.1	0.0	0.0	0.1	0.0	0	0.6
SB-3100M	0.5			5.0			0.0			0.03			0.1			5.6		
SB-2400M	0.3	0.3	0.0	2.8	0.7	1.1	0.0	0.0	0.2	—	—	0.1	0.1	0.0	0.1	3.2	1	1.5
SB-1360M	0.3	0.2	0.0	2.6	1.1	1.3	0.0	0.0	0.2	—	0.1	0.1	0.2	0.1	0.1	3.1	1.5	1.7
SB-140M	0.2	0.2	0.0	2.6	0.6	1.6	0.0	0.0	0.3	0.05	0.1	0.2	0.1	0.0	0.2	3.0	0.9	2.3
Ompompanoosuc River																		
OR-24050M	—	—	—	0.1	0.0	0.0	—	0.0	0.2	0.04	—	0.1	0.1	—	0.1	0.2	0	0.4
OR-23630M	0.1			0.4			—			0.03			0.1			0.6		
OR-23200M	0.4	0.3	0.0	1.1	0.5	0.5	0.0	0.0	0.2	0.09	0.1	0.1	0.1	0.0	0.1	1.7	0.9	0.9

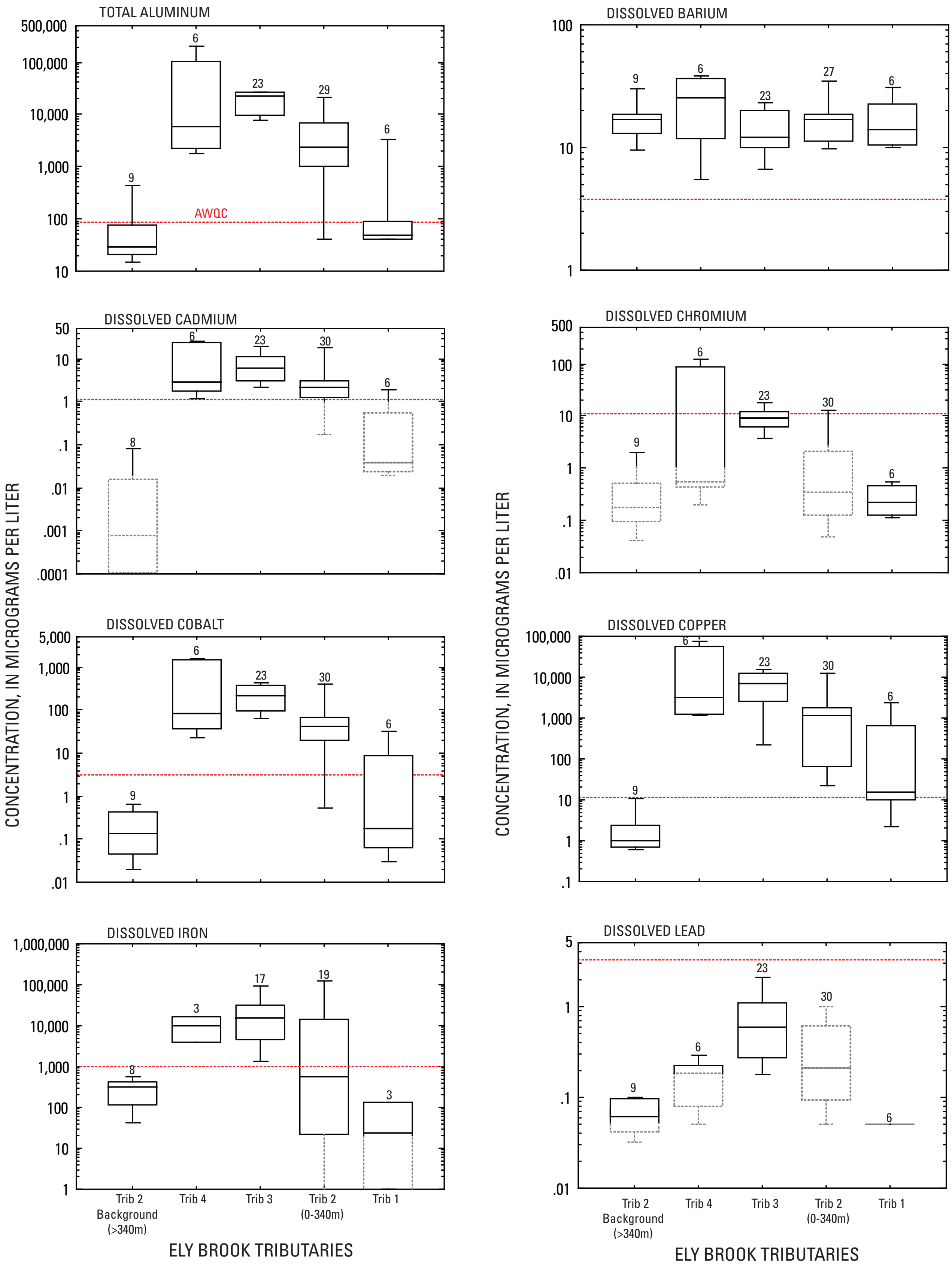


Figure 11. Select constituent concentrations in surface waters among four tributaries to Ely Brook at the Ely Mine Superfund site, Vershire, VT. Data are from this study and Argue and others (2008).

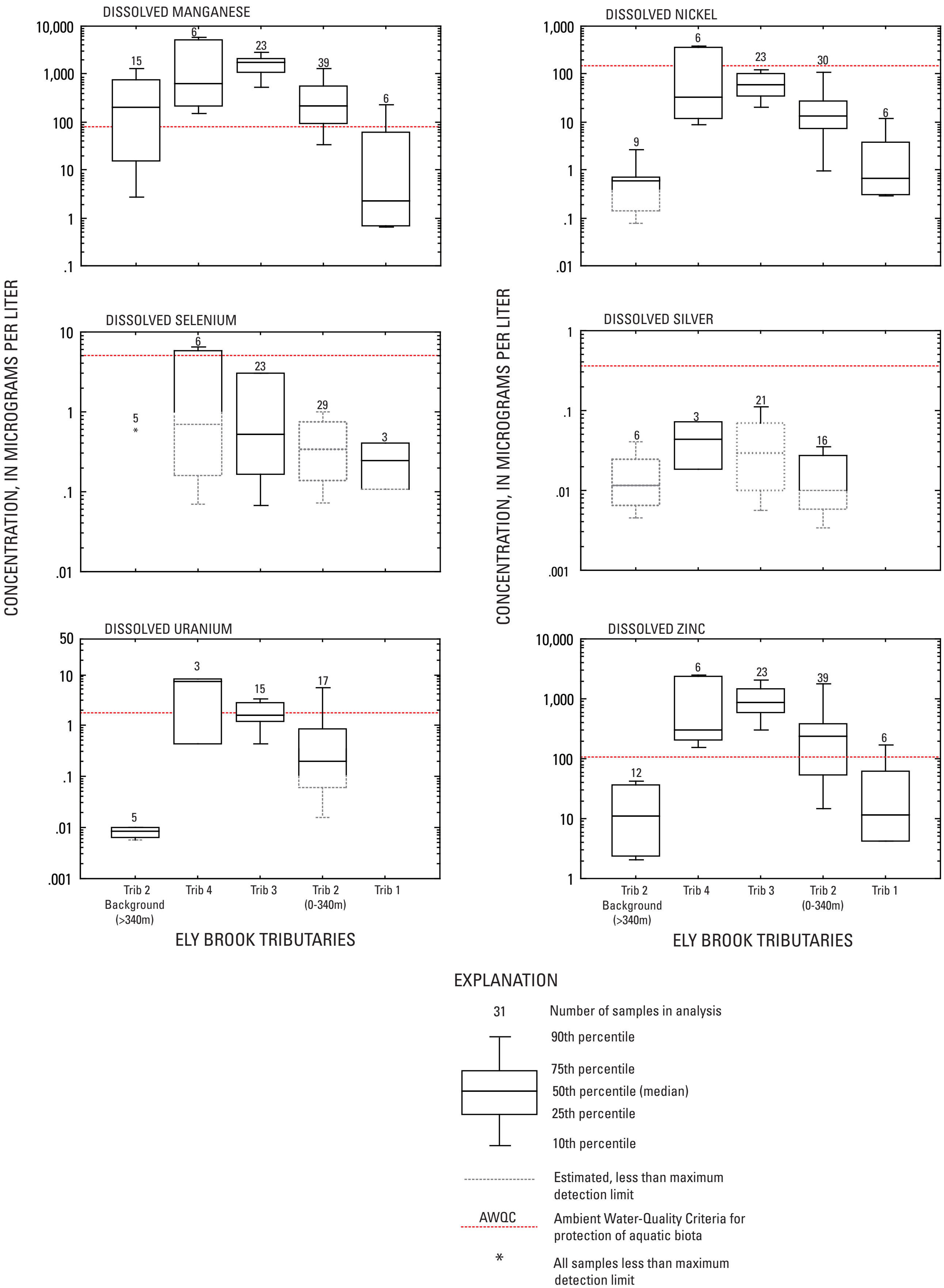


Figure 11. Select constituent concentrations in surface waters among four tributaries to Ely Brook at the Ely Mine Superfund site, Vershire, VT. Data are from this study and Argue and others (2008).—Continued

Concentrations of most elements in surface waters of tributaries 2, 3, and 4 were greater than background conditions by 1 to 4 orders of magnitude (fig. 11) with the exceptions being Ba, which was similar among all tributaries and background conditions (rho > 0.05), Cr, Fe, Mn, Se, and Ag, which were similar between tributary 2 and background conditions (rho > 0.05), and Se and Ag, which were similar between tributary 3 and background conditions (rho > 0.05).

Statistically significant differences were observed among tributaries for some trace-element concentrations. Most trace-element concentrations in tributary 1 were less than and significantly different from tributaries 2, 3, and 4 (rho < 0.05). However, Al and Cu concentrations were similar (rho > 0.05) between tributaries 1 and 2. Concentrations of Al, Cr, Co, Fe, Mn, Ni, U, and Zn in tributary 2 were generally less than and significantly different from tributary 3 (rho < 0.05). Concentrations of trace elements were similar between tributaries 2 and 4 (rho > 0.05) and between tributaries 3 and 4 (rho > 0.05) with the exception being lead in tributary 3, which was generally greater than and significantly different from tributary 4 (rho < 0.05).

Sediment Geochemistry

The major-element geochemistry of the pond sediments reflects their siliciclastic constituents. Chemical constituents for sediment samples are summarized in table 6, and complete analyses are reported in appendix 8. Aluminum concentrations ranged from 5.5 to 11.1 weight percent in the pond sediments, and was 6.7 weight percent in the reference pond, pond 1. Na, K, Ca, and Mg all ranged from 0.7 to 1.9 weight percent. Iron concentrations ranged from 3.5 to 5.8 weight percent in the pond sediments, and was 4.4 weight percent in the sediments of pond 1. Manganese concentrations were low, ranging between 443 and 3,130 mg/kg. Carbonate carbon concentrations are uniformly low, between 0.04 and 0.07 weight percent carbon, whereas total organic carbon concentrations in the pond sediments were high ranging from 6.5 to 10.4 weight percent. Total sulfur concentrations ranged between 0.34 and 0.93 weight percent.

The concentrations of trace elements were variable, with the exception of copper, which had a systematic increase downstream through the ponds from 81.7 to 3,540 mg/kg. The ranges in concentrations in pond sediments for Ag (<1 mg/kg), As (<1–7 mg/kg), Cd (0.2–2.5 mg/kg), Co (13.3–78.3 mg/kg), Cr (47–130 mg/kg), Hg (0.07–0.15 mg/kg), Mo (0.63–2.58 mg/kg), Ni (29.5–61.1 mg/kg), Pb (18.4–43.7 mg/kg), Sb (<0.05–1.42 mg/kg), Se (0.7–1.4 mg/kg), U (2.3–6.2 mg/kg), V (68–163 mg/kg), and Zn (68–507 mg/kg) did not correlate with distance downstream from the reference pond. None of the ponds exceeded the PEC values for As, Cd, Hg, Pb, or Zn. Pond 2 exceeded the Cr PEC, ponds 4 and 5 exceeded both the Cu and Ni PECs, and pond 6 only exceeded the Cu PEC. HIs for Cd, Cu, Ni, Pb, and Zn in pond sediments were above 1 at all sites (table 10). The values generally increase downstream from 2 in the reference pond to 27 in pond 5, and then the values drop to 13 in pond 6.

Ecological Indicators

An evaluation of the QMH invertebrate data sampled within the ponds indicated that impairment sequentially increased from pond 1 to 6, but that impairment was most severe beginning at pond 4, and continued downgradient from that location (fig. 8; table 9). For example, invertebrate richness at pond 1 was 59 taxa, which decreased to 47 at pond 3 (20 percent loss), but further decreased to 26 at pond 4 (56 percent loss). Although QMH-based invertebrate abundance is typically not considered a definitive metric of condition, it can often be used to indicate a relative degree of ecosystem function when sampling effort is standardized. Invertebrate abundance was highest at pond 1 (1,950 individuals) but was reduced an order of magnitude at pond 4 (194 individuals) and three orders of magnitude by pond 6 (2 individuals). Decreases in the values of abundance and richness were closely associated with the increase in surface-water metal concentrations, as characterized by the HIs derived for the sites (fig. 12; table 9). The in situ amphibian embryo-larval toxicity testing done in 2007 provides additional insights into the ecological health of the ponds. For these tests, wood frog egg masses were collected from an offsite reference pond and placed within enclosures in Ely Mine ponds 1, 4, and 5. Ponds 4 and 5 showed high mortality in recently hatched larvae, and pond 4 also had decreased larval survival over time (TechLaw, Inc., 2008).

Ely Brook

Surface-Water Geochemistry

Four sites were sampled in Ely Brook in August 2006, one of which was upstream of mine-impacted drainage and was also discussed in the background conditions section (EB-1080M). The three other Ely Brook sites include site EB-770M located 10 m downstream of Ely Brook tributary 4, site EB-600M located 200 m downstream of Ely Brook tributary 4 and upstream of Ely Brook tributary 2, and site EB-90M located downstream of Ely Brook tributary 1 and upstream of the confluence with Schoolhouse Brook. Data from these sites from this study will be used to examine downstream variations in chemistry. Chemical constituents for surface-water samples are summarized in table 4, and complete analyses are reported in appendix 6.

Field Parameters and Major Inorganic Constituents

The pH of Ely Brook fluctuated from 7.2 at background site EB-1080M to 6.3 at EB-770M to 7.0 at EB-600M and then decreased drastically to 3.2 at EB-90M. In contrast to pH, specific conductance increased from 87 µS/cm (EB-1080M) to 149 µS/cm (EB-770M), then decreased to 123 µS/cm (EB-600M), and then increased drastically to 447 µS/cm (EB-90M) (fig. 5). The major dissolved cations (Ca, K, Mg, Na, SiO_2) and hardness fluctuated in the same manner as the specific conductance. Calcium (13.4 to 21.1 mg/L) and SiO_2 (9.1 to 33.1 mg/L) were the dominant dissolved cations and occurred in subequal proportions; other major cations include

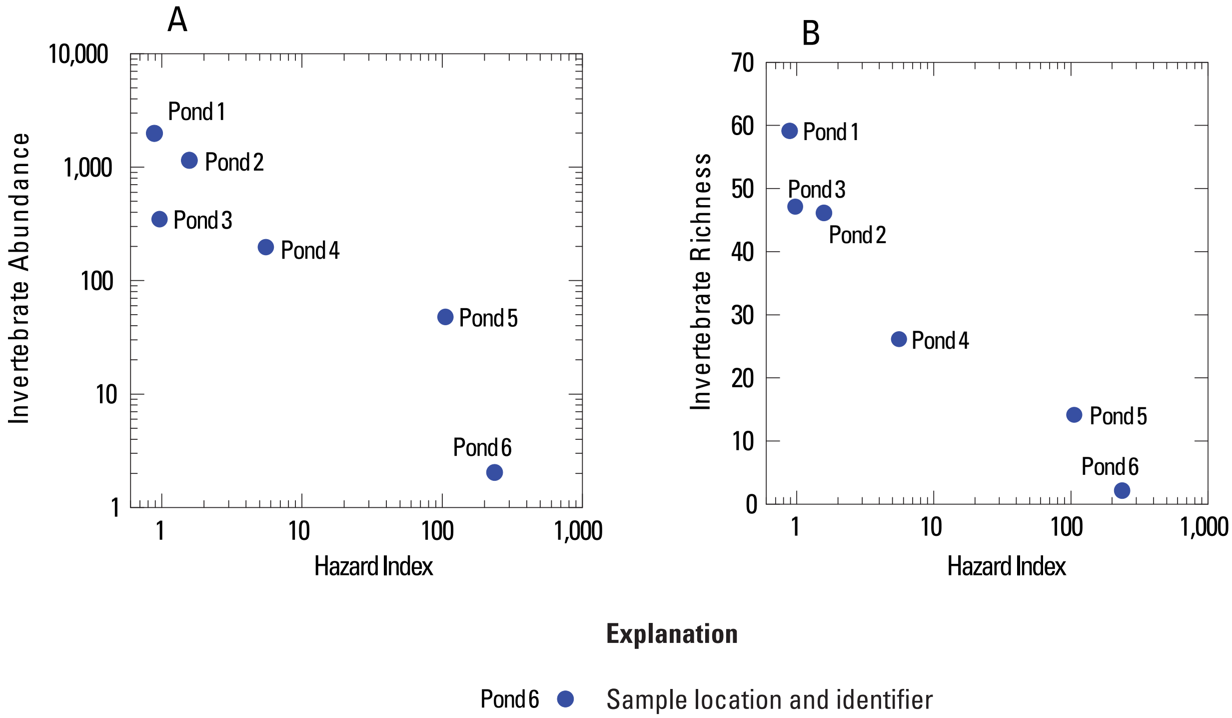


Figure 12. Qualitative multi-habitat (QMH) invertebrate *(A)* abundance and *(B)* richness values relative to the gradient in hazard index values derived from trace metal concentration in surface-waters from the Ely ponds, Vershire, VT.

K (1.69 to 3.42 mg/L), Mg (1.18 to 5.54 mg/L), and Na (1.12 to 2.3 mg/L). Alkalinity was the dominant anionic species in the background conditions sample (EB-1080M) with a concentration of 41 mg/L $CaCO_3$ (fig. 6). In contrast, sulfate dominated in the mine-impacted Ely Brook samples (EB-770M to EB-90M) with concentrations ranging from 36 to 143 mg/L (fig. 6). In comparison, chloride concentrations only reached 2.6 mg/L. Previous reports found similar results (Seal and others, 2001; Holmes and others, 2002; Argue and others, 2008).

Iron, Aluminum, and Manganese

The concentrations of dissolved Mn (92.8 to 217 µg/L) were considerably higher than the concentrations of dissolved Al (3.4 to 25.1 µg/L) and Fe (<20 to 22 µg/L) in the three most upstream Ely Brook surface waters (EB-1080M, EB-770M, and EB-600M) (fig. 7). In contrast, Fe (6,370 µg/L) and Al (4,190 µg/L) dominated at EB-90M in comparison to Mn (521 µg/L). The concentrations of dissolved aluminum and manganese followed the same trends downstream as the major cations and anions discussed above. Specifically, the concentrations of aluminum and manganese increased from EB-1080M to EB-770M, then decreased at EB-600M, and then increased drastically at EB-90M.

Minor and Trace Inorganic Elements

The only minor and trace elements present in significant concentrations in August 2006 in Ely Brook were Ba (17 to 19.9 µg/L), Cd (<0.02 to 1.99 µg/L), Co (0.08 to 63 µg/L), Cu (1.3 to 1,560 µg/L), Ni (0.5 to 19.5 µg/L), Sr (47.6 to 64 µg/L), and Zn (5.6 to 373 µg/L) (fig. 7). In comparison, historical variations for Ely Brook showed a greater range (appendix 2). For example, historical dissolved copper concentrations, the most significant contaminant, approach 8,000 µg/L (Argue and others, 2008). Trace amounts of dissolved Be (up to 0.3 µg/L), Pb (up to 0.95 µg/L), and U (up to 0.42 µg/L) were detected in some samples. The minimum value reported above was generally for background site EB-1080M, whereas the maximum value was for the farthest downstream site (EB-90M). The following elements follow this trend: Be, Cd, Co, Cu, Ni, Pb, Sr, U, and Zn. Dissolved Ag, As, Hg, Sb, Se, Tl, and V concentrations were all below their detection limits.

Dissolved Organic Carbon and Nutrients

DOC concentrations throughout Ely Brook ranged from 0.8 to 1.9 mg/L. Nutrients were generally low throughout the study area. Total dissolved nitrogen ranged from 0.04 to 0.07 mg/L, and total dissolved phosphorus ranged from 0.002 to 0.004 mg/L.

Trace Element Loads

Coupled streamflow measurements and surface-water samples obtained at sites EB-90M, EB-600M, EB-770M, and EB-1080M on August 23, 2006, were used to describe transport and attenuation of constituents in Ely Brook. Background conditions were characterized by samples obtained at EB-1080M. Instantaneous loads for most elements increased above background conditions by 1 to 2 orders of magnitude at EB-770M, below the confluence with Ely Brook tributary 4 (fig. 13). Total iron loads, however, were similar. As waters

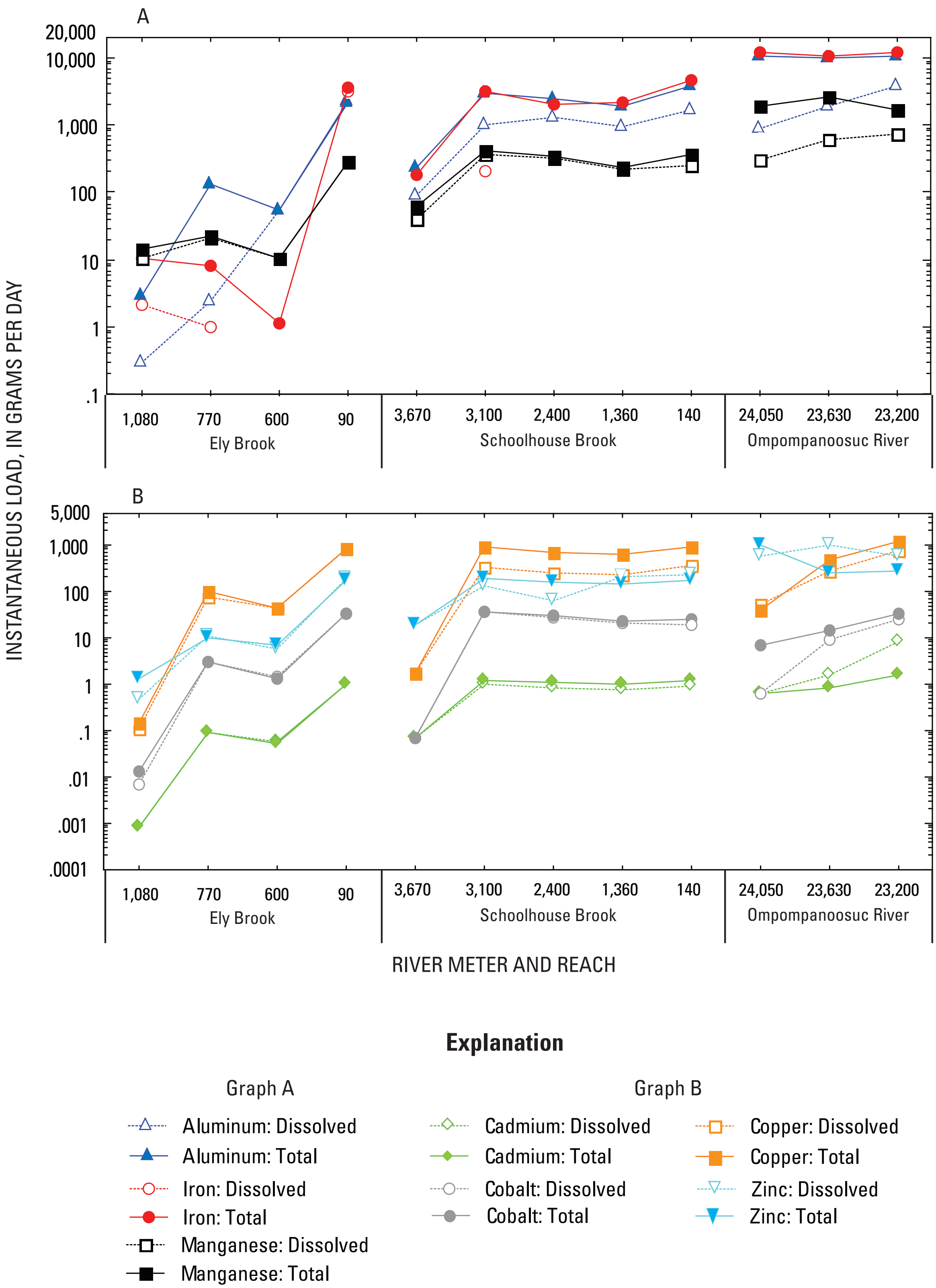


Figure 13. Instantaneous *(A)* aluminum, iron, and manganese, and *(B)* cadmium, cobalt, copper, and zinc loads at the Ely Mine Superfund site, Vershire, VT.

traveled downstream from EB-770M to EB-600M, there was a marked decrease in element loads. More than 50 percent of the total aluminum load and more than 50 percent of the total and dissolved manganese loads were removed. This is most likely the result of aluminum hydrolysis and manganese oxidation and hydrolysis. Instantaneous loads for most elements increased by 1 to 3 orders of magnitude as waters traveled from EB-600M to EB-90M because water from Ely Brook tributaries 1 and 2 drains into Ely Brook. The pH decreased from 6.9 to 3.2 from EB-600M to EB-90M and resulted in most element loads being dominated by the dissolved phase (fig. 13).

Comparisons with Ambient Water-Quality Criteria and Relations among Reaches

Ely Brook was partitioned into four reaches for analysis of water data based on the relationship to confluences with tributaries 1, 2, and 4. Stream reach 1, defined by locations sampled from river meter 0 to 350, was partitioned to describe water-quality conditions near the mouth of Ely Brook. Stream reach 2, defined by locations sampled from river meter 350 to 540, was partitioned to describe water-quality conditions downstream of the confluence with Ely Brook tributary 2. Stream reach 3, defined by locations sampled from river meter 540 to 800, was partitioned to describe water-quality conditions downstream of the confluence with Ely Brook tributary 4. Insufficient water samples were collected in stream reach 3 to allow for statistical analysis of variance for most trace elements. Background conditions were characterized by locations sampled above river meter 800.

Concentrations greater than AWQC were observed in stream reach 1 for Al, Ba, Cd, Co, Cu, Fe, Mn, Hg, Ag, and Zn; in stream reach 2 for Al, Ba, Cd, Cr, Co, Cu, Fe, Mn, Ag, U, and Zn; and in stream reach 3 for Al, Ba, Co, Cu, Mn, and Zn (appendix 5). Concentrations of most elements in reaches 1 and 2 were generally greater than background conditions by 1 to 3 orders of magnitude (fig. 14) with the exception of Ba and Ag, which were similar among reaches and background conditions (rho > 0.05). Concentrations of Co, Cu, and Ni in reach 3 were generally greater than and significantly different from (rho < 0.05) background conditions.

Concentrations of most elements increased with distance downstream in Ely Brook (fig. 14). Concentration of Al, Ba, Cd, Cr, Co, Cu, Mn, and Zn were similar between stream reaches 1 and 2 (rho > 0.05). However, concentrations of Fe and U in reach 1 and Al in reach 3 generally were less than and statistically different from reach 2 (rho < 0.05). Median concentrations of most constituents decreased between reaches 2 and 1, most likely the result of iron oxidation, iron and aluminum hydrolysis, and sorption of associated metals. Based on the dramatic change in slope (table 2) and the observed pH of surface and pore waters (tables 4 and 5), this metal cycling may be occurring as groundwaters with higher pH discharge to the stream or as surface waters flow through the hyporheic zone and interact with shallow groundwater (Harvey and Fuller, 1998; Fuller and Harvey, 2000).

Pore-Water Geochemistry

Pore-water samples from Ely Brook were co-located with surface-water sites. The sites include EB-1080M, EB-770M, EB-600M, and EB-90M; SB-3670M is also discussed in the background conditions section. Chemical constituents for pore-water samples are summarized in table 5, and complete analyses are reported in appendix 7.

Field Parameters and Major Inorganic Constituents

The pH and specific conductance were measured only on the in situ and equilibrated samples. The pH values for the in situ and equilibrated samples were comparable, and pH in the pore waters followed the same fluctuating trend as pH in the surface waters from the same sites (fig. 5). The pH decreased from EB-1080M to EB-770M, then increased at EB-600M, and then decreased drastically at EB-90M. The specific conductance, which was significantly higher in the equilibrated versus in situ splits, followed a reverse trend to the pH (fig. 5). A wide range in both pH and specific conductance occurred along Ely Brook; pH ranged from 2.9 to 7.5, and specific conductance ranged from 85 to 1,063 µS/cm.

Calcium and silica were the dominant dissolved cations, and K, Mg, and Na occur in lesser but subequal proportions; these relative proportions in the pore waters were similar to those in the surface waters. The concentrations of these elements in the pore waters fluctuated downstream; in general for each pore-water type, the lowest concentrations were found in the background site (EB-1080M), and the highest concentrations were found in the farthest downstream site (EB-90M). Also, the concentrations of the dissolved major cations were usually highest in the equilibrated samples (Ca: 21.6–69.5 mg/L; Mg: 3.16–9.29 mg/L; Na: 2.4–4.23 mg/L; K: 4.04–7.32 mg/L; SiO_2: 12.7–39.5 mg/L), and lowest in the in situ samples (Ca: 12.6–20.4 mg/L; Mg: 1.18–5.43 mg/L; Na: 1.13–2.34 mg/L; K: 1.68–4.87 mg/L; SiO_2: 9–32.8 mg/L). In general, the concentrations of major cations in the in situ waters were comparable to their concentrations in the surface waters. The hardness values of the pore waters followed the trends displayed by the major cations with the highest hardness found in equilibrated pore waters and the lowest values for in situ pore waters; in situ values were comparable to surface-water values. Alkalinity was the dominant anionic species in the background pore waters (EB-1080M) as with surface water, whereas sulfate dominated in the mine-impacted samples (EB-770M, EB-600M, and EB-90M) (fig. 6). Like the dissolved major cations, these anions were found in higher concentrations in the equilibrated samples than in the in situ samples. Alkalinity was not measured on the centrifuged splits because of insufficient sample volumes. The alkalinity and sulfate values of the in situ pore waters were generally equivalent to the alkalinity of the surface water (fig. 6).

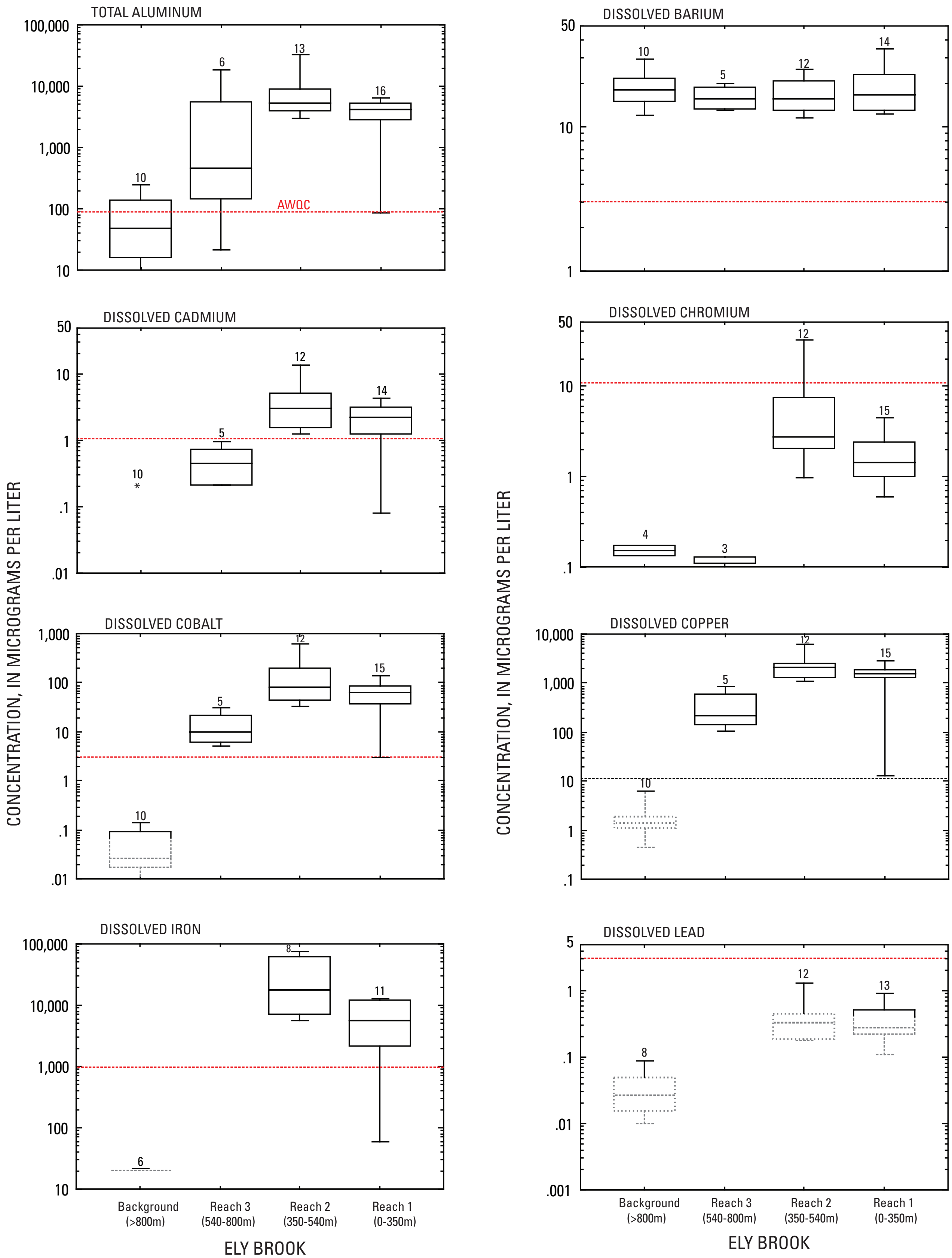


Figure 14. Select constituent concentrations in surface waters among four reaches in Ely Brook at the Ely Mine Superfund site, Vershire, VT. Data are from this study and Argue and others (2008).

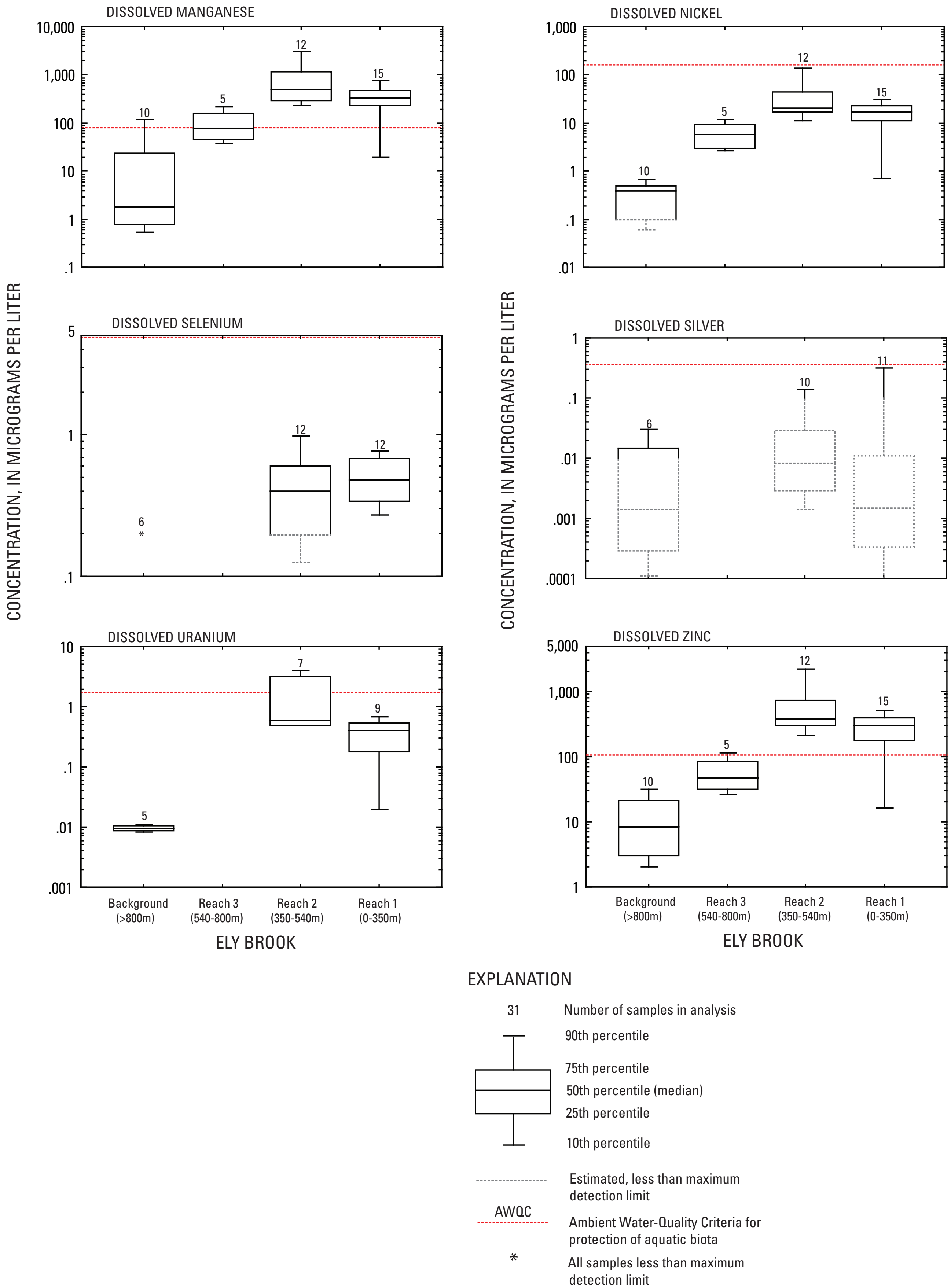


Figure 14. Select constituent concentrations in surface waters among four reaches in Ely Brook at the Ely Mine Superfund site, Vershire, VT. Data are from this study and Argue and others (2008).—Continued

Iron, Aluminum, and Manganese

The concentrations of dissolved Fe, Al, and Mn in pore waters fluctuated downstream according to the same variations seen in the major dissolved cations and anions discussed above. For the in situ pore-water types, the lowest concentrations were found in the background sample (EB-1080M) and the highest were found in the farthest downstream site (EB-90M) (fig. 7). Iron was usually and Al was always the highest in the centrifuged splits with concentrations that ranged from 32 to 163,100 mg/L for Fe and 50.4 to 7,520 mg/L for Al. In contrast to Fe and Al, Mn was the highest in the equilibrated splits with concentrations that ranged from 418 to 5,460 mg/L.

Minor and Trace Inorganic Elements

The minor and trace elements present in pore waters from Ely Brook were Ba (12.9 to 74.7 μg/L), Cd (<0.02 to 2.87 μg/L), Co (<0.02 to 272 μg/L), Cu (2.4 to 2,140 μg/L), Ni (0.6 to 39 μg/L), Pb (<0.05 to 1.9 μg/L), Se (<1 to 2.9 μg/L), Sr (46.1 to 225 μg/L), and Zn (1.5 to 616 μg/L (fig. 7). The highest concentrations of Cd, Co, Cu, Ni, Pb, Se, and Zn were generally found in the pore waters from the farthest downstream site (EB-90M), and their lowest concentrations were generally in the pore waters from the background site (EB-1080M). The equilibrated and centrifuge samples generally contained higher concentrations of these elements compared to the in situ samples. Beryllium (up to 0.3 μg/L), Cr (up 2.1 μg/L), and Sb (up to 0.77 μg/L) were only detected in the EB-90M pore waters. Uranium was detected in EB-1080M (up to 0.49 μg/L) and EB-90M (up to 1.01 μg/L). Similar to surface waters, dissolved Ag, As, Hg, Tl, and V concentrations in all pore waters were near or below their detection limits.

Dissolved Organic Carbon and Nutrients

DOC and nutrient concentrations were determined only on the in situ pore-water samples. DOC concentrations throughout Ely Brook ranged from 1.0 to 1.6 mg/L. Nutrients were generally low throughout the brook with total dissolved nitrogen ranging from 0.04 to 0.17 mg/L and total dissolved phosphorus ranging from 0.003 to 0.004 mg/L.

Comparisons with Ambient Water-Quality Criteria

In the previous section, which discussed surface water in Ely Brook, sample sites were partitioned on the basis of stream reach and compared to ambient water-quality criteria. Hardness-dependent criteria were calculated on the basis of the hardness of the sample. This section will refer to the same stream reaches although pore waters are from this study, whereas surface waters included all historical samples. Pore waters were not sampled prior to this investigation. As in the previous section, stream reach 1 refers to water-quality conditions near the mouth of Ely Brook and downstream of Ely Brook tributary 1 (EB-90M); stream reach 3 refers to samples downstream of the confluence with Ely Brook tributary 4 and include sites EB-770M and EB-600M, and stream reach 4 refers to background samples (EB-1080M). Pore waters were not collected in stream reach 2, which was downstream of Ely Brook tributary 2 and upstream of Ely Brook tributary 1.

In stream reach 1, the concentrations of the following elements exceeded their AWQCs in all samples: Al, Ba, Cd, Co, Cu, Fe, Mn, and Zn. Farther upstream in stream reach 3, the concentrations of Ba, Cd, and Cu in all pore waters exceeded their AWQC. Other exceedances in this stream reach include: Al in the centrifuged sample from EB-600M and Co and Mn from the equilibrated and centrifuged samples of EB-770M and the equilibrated sample of EB-600M. The concentrations for most elements in pore waters in stream reach 4, the background site (SB-3670M), were less than AWQC with the exceptions being Al and Cd in the centrifuged sample, Ba in all pore waters, and Mn in equilibrated pore water.

Sediment Geochemistry

Sediment samples from Ely Brook include the four sites previously discussed (EB-1080M, EB-770M, EB-600M, and EB-90M) and an additional sample collected from site EB-90M from the uppermost layer of the overbank sediment. Chemical constituents for sediment samples are summarized in table 6, and complete analyses are reported in appendix 8. SEM-AVS data for sediment samples are summarized in table 7, and complete analyses are reported in appendix 4. This additional sample, EB-90M-OBS, was a grab sample of one discrete area instead of a composite of a larger section of the stream reach. The major element geochemistry of the background samples from Ely Brook (EB-1080M) reflected its siliciclastic constituents with 4.26 weight percent Al, 2.76 weight percent Fe, and between 0.98 and 1.05 weight percent Ca, K, Mn, and Na. In contrast, the mine-impacted sediment samples contained Fe > Al > Ca, K, Mg, and Na. In general, the concentration of Fe increased downstream, whereas the concentrations of Al, Ca, K, Mg, and Na decreased. The variation in Fe concentrations was the greatest and ranged from 5.5 weight percent at EB-770M to 16.7 weight percent at EB-90M and 36.3 weight percent at EB-90M-OBS. Also, sulfur increased from 0.04 weight percent at the background to 1.86 weight percent at EB-90M and 4.66 weight percent at EB-90M-OBS. Carbonate carbon was low, between 0.01 and 0.04 weight percent carbon. In contrast, total organic carbon was significantly higher than carbonate carbon and ranged from 0.23 to 0.53 weight percent for EB-1080M to EB-90M; the concentrations of organic carbon in EB-OBS was considerably higher at 2.42 weight percent.

Maximum concentrations of trace elements in the Ely Brook stream sediments were 17 mg/kg for Ag (EB-90M-OBS), 4 mg/kg for As (EB-90M), 360 mg/kg for Ba (EB-90M-OBS), 1 mg/kg for Cd (EB-600M and EB-90M), 65.5 mg/kg for Co (EB-600M), 89 mg/kg for Cr (EB-90M-OBS), 5,950 mg/kg for Cu (EB-90M), 2,200 mg/kg for Mn (EB-90M), 44.5 mg/kg for Mo (EB-90M-OBS), 23.4 mg/kg for Ni (EB-600M), 174 mg/kg for Pb (EB-600M), 2.03 mg/kg for Sb (EB-90M), 71.1 mg/kg for Se (EB-90M-OBS), 133 mg/kg for Sr (EB-1080M), and 206 mg/kg for Zn (EB-90M). The maximum concentrations of many of these elements were found in sediments from the farthest downstream reach of the stream (EB-90M and EB-90M-OBS). Mercury was below its detection limit of 0.02 mg/kg in all sediments except EB-90M-OBS with 0.13 mg/kg.

Acid volatile sulfide for the stream-sediment samples from Ely Brook was below the detection limit of 23 mg/kg (0.7 µmoles/g). The sum of the concentrations of simultaneously extracted metals (Cd + Cu + Pb + Ni + Zn) was low in the background sample (EB-1080M) at 0.5 µmol/g and increased to 5.7 µmol/g (EB-770M) and 14.5 µmol/g (EB-600M). The concentration of SEM then decreased to 1.2 µmol/g at EB-90M. The samples from Ely Brook were the only ones in this study to contain detectable simultaneously extracted cadmium concentrations. Simultaneously extracted mercury was below its detection limit of 0.001 µmol/g.

The concentrations of As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn in the sediments from Ely Brook are below the PEC limits, with the exception of Cu and Pb. The concentrations of copper in all sediments that were impacted by the mine (EB-770M, EB-600M, and EB-90M) exceeded the PEC of 149 mg/kg with values that ranged from 1,160 to 5,950 mg/kg. Also, the concentrations of lead in EB-600M sediment exceeded its PEC of 128 mg/kg with a concentration of 174. The (ΣSEM-AVS)/f_{OC} values for the background stream sediment from Ely Brook was –61.5 µmol/gOC, which was well within the no-effects range. In contrast, the (ΣSEM-AVS)/f_{OC} for sediments EB-770M and EB-90M were 963.8 and 213.1 µmol/gOC, respectively, which fall within the uncertain effects range (USEPA, 2005). Also, the (ΣSEM-AVS)/f_{OC} for sediment EB-600M was 6,050 µmol/gOC, which falls within the predicted effects range, which has a lower limit of 3,000 µmol/gOC (USEPA, 2005).

Bioassay Results

For the Ely Brook sediment samples, tests were conducted using *Hyalella azteca* for 28-day exposures and *Chironomus dilutus* for 12-day exposures (table 8). For both organisms, survival and growth endpoints were measured. For EB-1080M, the reference site, *H. azteca* had an acceptable survival at 93.8 ± 1.8 percent, and growth of 3.24 ± 0.05 mm. At EB-770M, survival dropped to 68.8 ± 5.8 percent, and growth was 2.45 ± 0.06 mm. At EB-600M, survival dropped to 6.3 ± 2.6 percent, and growth was 1.96 ± 0.11 mm. At EB-90M, the site with the most impaired surface- and pore-water quality, survival was a surprising 91.3 ± 4.0 percent, and growth was 3.39 ± 0.06 mm.

The midge (*C. dilutus*) results were somewhat different. Site EB-1080M, the reference, had survival at 63.8 ± 6.5 percent, and growth was 1.21 ± 0.11 mm. At EB-770M, survival was statistically identical at 61.3 ± 4.8 percent, and growth dropped to 0.61 ± 0.11 mm. At EB-600M, survival was statistically identical at 65.0 ± 6.0 percent, and growth was 0.28 ± 0.01 mm. At EB-90M, the site with the most impaired surface- and pore-water quality, survival increased to 72.5 ± 4.5 percent, and growth was 1.73 ± 0.37 mm.

Relations among Trace Elements in Surface Water, Pore Water, Sediment, and Aquatic Biota

Surface water, pore water, and sediments were sampled in August 2006, and invertebrates were sampled in September 2006 at river meters 90, 600, 770, and 1,080 to relate water and sediment quality to aquatic biota. Background conditions were characterized by samples obtained at river meter 1,080. HIs at the background location were less than 1 for the surface-water sample and greater than 1 for the pore-water and sediment samples (table 10). However, no HQ greater than 1 was observed in pore water or sediments (table 10). HIs below the confluence with Ely Brook tributary 4 were greater than 1 for all samples and ranged from 50 to 237 in surface waters, 9.2 to 279 in pore waters, and 8.7 to 41 in sediments (table 10).

An evaluation of the RTH and DTH invertebrate data sampled at the Ely Brook sites indicated severe impairment below the reference location EB-1080M. Between EB-1080M and EB-770M, RTH abundance decreased from 1,756 to 8 individuals, and RTH richness decreased from 43 to 7 taxa (fig. 9); DTH abundance decreased from 415 to 8 individuals, and DTH richness decreased from 34 to 7 taxa (figs. 9 and 10; table 9). A decrease in the values of these two metrics also was closely associated with the increase in HIs for metals concentrations in surface water (RTH abundance and richness decrease, fig. 15; table 9) and pore water (DTH abundance and richness decrease, fig. 16; table 9). This response with HI values was definite (rho = –1.000) for richness in both the RTH and DTH assemblages, even though an increase in HIs did not follow an up- to downgradient order in the surface-water samples. These results indicated that the RTH and DTH invertebrate assemblages in Ely Brook were strongly affected by acid-mine drainage and that the level of contamination in the respective habitat (surface or pore water) is a relevant environmental factor in the response.

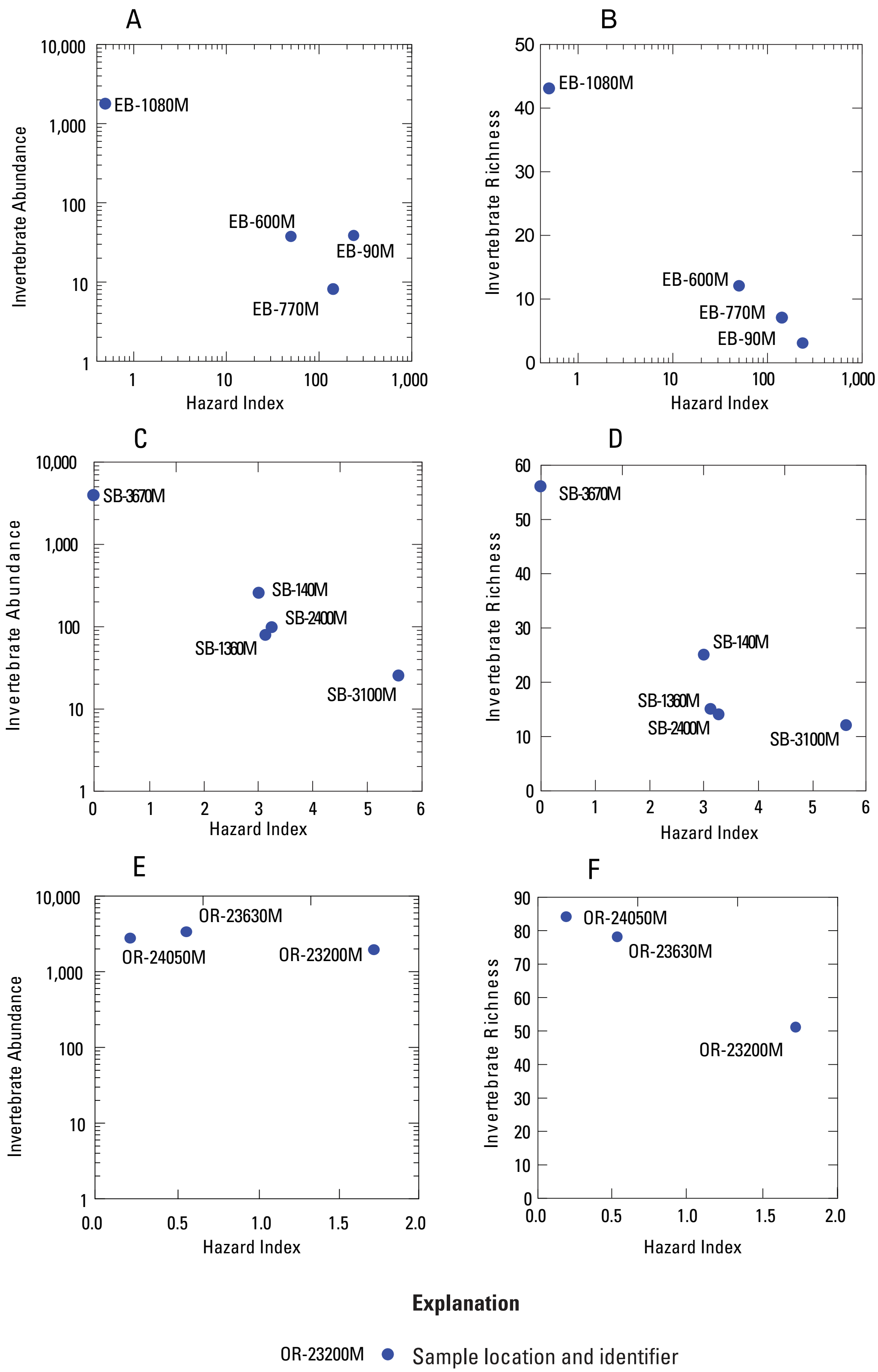


Figure 15. Riffle-targeted habitat (RTH) invertebrate *(A)* abundance and *(B)* richness values in Ely Brook, *(C)* abundance and *(D)* richness values in Schoolhouse Brook, and *(E)* abundance and *(F)* richness values in the Ompompanoosuc River relative to the gradient in hazard index values derived from trace metal concentration in surface waters, Vershire, VT. The first location in each of the frames (lowest hazard index value) was coincidentally farthest upgradient from sources of contamination and was used to represent background conditions for the stream.

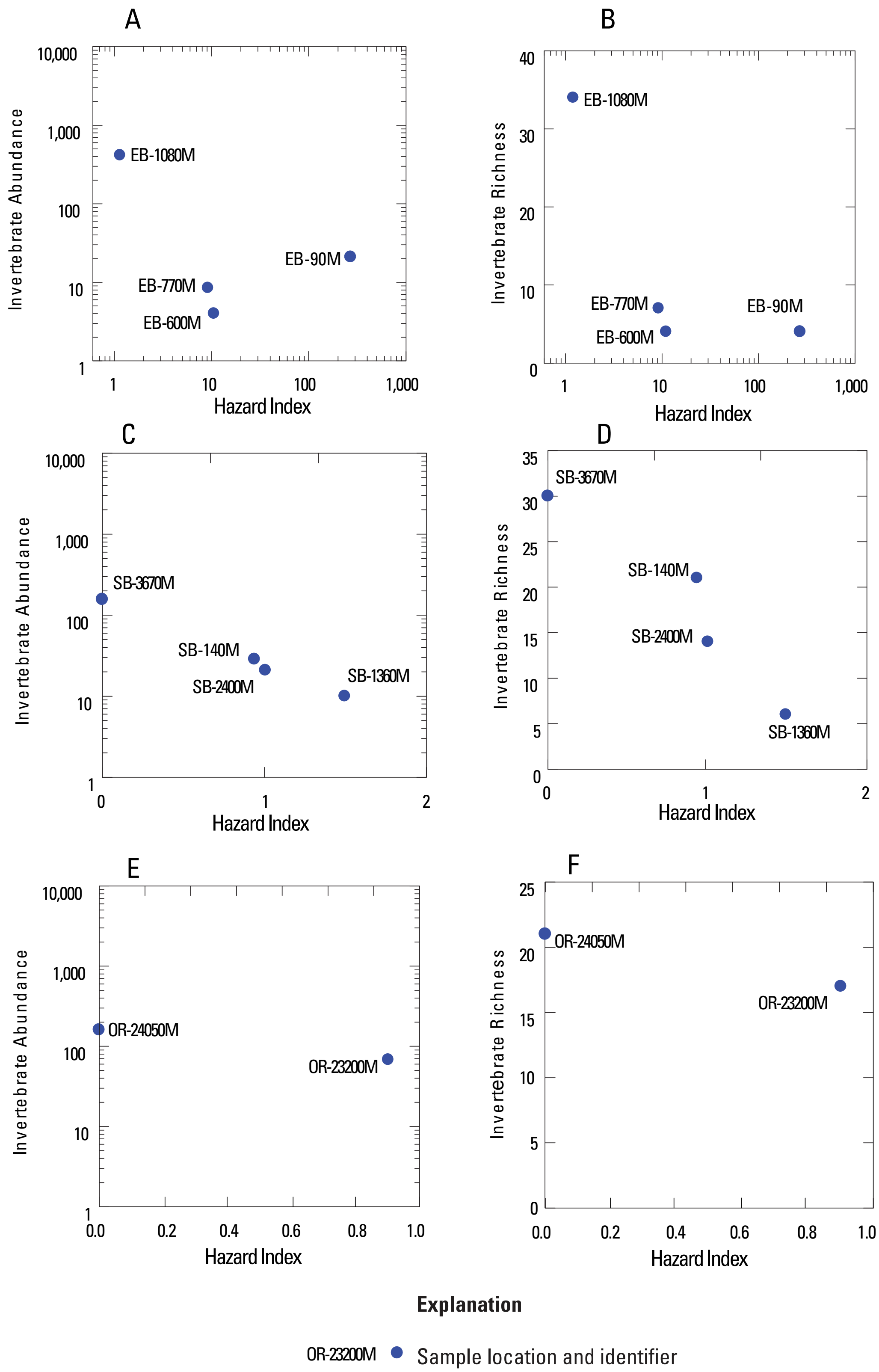


Figure 16. Depositional-targeted habitat (DTH) invertebrate *(A)* abundance and *(B)* richness values in Ely Brook, *(C)* abundance and *(D)* richness values in Schoolhouse Brook, and *(E)* abundance and *(F)* richness values in the Ompompanoosuc River relative to the gradient in hazard index values derived from trace metal concentration in pore waters, Vershire, VT. The first location in each of the frames (lowest hazard index value) was coincidentally farthest upgradient from sources of contamination and was used to represent background conditions for the stream.

Schoolhouse Brook

Surface-Water Geochemistry

Five sites were sampled in Schoolhouse Brook in August 2006, one of which was upstream of the confluence with Ely Brook and was also discussed in the background conditions section (SB-3670M). Chemical constituents for surface-water samples are summarized in table 4, and complete analyses are reported in appendix 6. The four other Schoolhouse Brook sites include site SB-3125M, located approximately 125 m downstream from the confluence with Ely Brook, site SB-2400M, located approximately 850 m downstream from the confluence, site SB-1360M, located approximately 1,890 m downstream from the confluence, and site SB-140M, located approximately 3,110 m downstream from the confluence with Ely Brook and 140 m upstream of the confluence with the Ompompanoosuc River. Data from these sites will be used to examine downstream variations in chemistry.

Field Parameters and Major Inorganic Constituents

The pH of Schoolhouse Brook decreased slightly from 8.2 (SB-3670M) to 7.8 (SB-3125M) downstream of the confluence with Ely Brook due to mixing with acidic waters from Ely Brook (pH 3.2 at EB-90M) (fig. 5). In contrast to the pH, the specific conductance and concentrations of most major dissolved cations did not vary significantly directly downstream from Ely Brook (fig. 5). However, most major dissolved cations increased slightly from SB-3125M to SB-2400M and then decreased farther downstream (SB-1360M and SB-140M). This is reflected in the hardness (in mg/L $CaCO_3$) increasing from 95.9 at SB-3125M to 97.8 at SB-2400M, and then decreasing to 92.5 and 84.2 at SB-1360M and SB-140M, respectively (fig. 6). The decrease downstream may be due to dilution after mixing with a tributary downstream of SB-2400M. Alkalinity, the dominant anionic species, followed similar trends to hardness and ranged from 80 to 99 mg/L $CaCO_3$ (fig. 6). Chloride and sulfate concentrations reached 5 and 16 mg/L, respectively; they did not vary significantly downstream in Schoolhouse Brook. Calcium was the dominant dissolved cation and ranged from 30.7 to 35.8 mg/L. Other major cations include K (2.2 to 2.42 mg/L), Mg (1.82 to 2.03 mg/L), Na (3.77 to 4.62 mg/L), and SiO_2 (7.3 to 9.1 mg/L). Previous reports found similar results (Seal and others, 2001; Holmes and others, 2002; Argue and others, 2008).

Iron, Aluminum, and Manganese

The concentrations of dissolved Al (93.5 to 128 µg/L) were considerably higher than the concentrations of dissolved Fe (<20 to 49 µg/L) and Mn (13.6 to 43.8 µg/L) in Schoolhouse Brook surface waters (excluding background site SB-3670M) (fig. 7). All three elements increased directly downstream from the confluence with Ely Brook due to mixing with the more concentrated waters of Ely Brook. Iron and manganese generally decreased downstream from SB-3125M to SB-140M.

Minor and Trace Inorganic Elements

The only minor and trace elements present in significant concentrations in August 2006 in Schoolhouse Brook downstream of the confluence with Ely Brook were Ba (14.8 to 19.8 µg/L), Co (1.1 to 4.31 µg/L), Cu (20.4 to 42.8 µg/L), Ni (1 to 1.4 µg/L), Sr (134 to 158 µg/L), and Zn (6.6 to 19.8 µg/L). In comparison, historical variations for Schoolhouse Brook show a greater range (Argue and others, 2008). For example, dissolved copper concentrations, the most significant contaminant, ranged from approximately 6 to 100 µg/L. Trace amounts of dissolved Cd (up to 0.12 µg/L), Pb (up to 0.1 µg/L), Sb (0.78 µg/L), and U (up to 0.31 µg/L) were detected in some or all samples. The concentrations of most of these elements were below their detection limits upstream of Ely Brook at SB-3670M and increase at SB-3125M due to mixing with the more concentrated water of Ely Brook (fig. 7). Dissolved Ag, As, Be, Cr, Hg, Se, Tl, and V concentrations were all below their detection limits.

Dissolved Organic Carbon and Nutrients

DOC concentrations throughout Schoolhouse Brook ranged from 1.2 to 2 mg/L. Nutrients were generally low throughout the study area. Total dissolved nitrogen ranged from 0.09 to 0.12 mg/L, and total dissolved phosphorus ranged from 0.003 to 0.006 mg/L.

Trace-Element Loads

Coupled streamflow measurements and surface-water samples obtained at SB-140M, SB-1360M, SB-2400M, SB-3100M, and SB-3670M on August 21 and 22, 2006, were used to describe the transport and attenuation of constituents in Schoolhouse Brook. Background conditions were characterized by samples obtained at SB-3670M. Instantaneous loads for most elements increased above background conditions at river meter 3,100, below the confluence with Ely Brook, and decreased with distance from SB-3125M to SB-1360M (fig. 13). An increase in instantaneous loads for most elements was observed from SB-1360M to SB-140M, most likely the result of samples being collected at different streamflow regimes. Streamflow at SB-140M was measured on August 21 at a probability of exceedance of approximately 40 percent, whereas streamflow at the other locations was measured on August 22 at a probability of exceedance of approximately 50 percent. Normalizing streamflow by drainage area at each location shows a marked increase in runoff per unit increase in drainage area at SB-140M relative to other locations.

Comparisons with Ambient Water-Quality Criteria and Relations among Reaches

Schoolhouse Brook was divided into three reaches for analysis of water data based on the proximity to runoff associated with the Ely Mine site and the confluence with a tributary. Stream reach 1, defined by locations sampled from river meter 0 to 2,915, was separated to describe water-quality conditions above the mouth of Schoolhouse Brook. Stream reach 2, defined by locations sampled from river meter 2,915 to 3,270, was partitioned to describe water-quality conditions downstream of the confluence with Ely Brook and above a major tributary to Schoolhouse Brook. Stream reach 3, defined by locations sampled above river meter 3,270, was partitioned to describe background conditions.

Concentrations in surface waters greater than AWQC were observed in reaches 1 and 2 for Al, Ba, Co, Cu, and Hg (appendix 5). Concentrations of Al, Ba, and Cu in reach 1 and Al, Ba, Co, and Cu in reach 2 were generally greater than AWQC (fig. 17) and significantly different from (rho < 0.05) background conditions. Concentrations of Cd, Co, Fe, Mn, and Ni in reach 1 were generally were less than AWQC (fig. 17) but significantly different from (rho < 0.05) those observed in reach 2, most likely due to dilution with waters from tributaries, as indicated by the limited variations in the loads of these elements in Schoolhouse Brook (fig. 13).

Pore-Water Geochemistry

Pore-water samples from Schoolhouse Brook were collected with surface-water samples except for site SB-3125M. The sites include SB-3670M, SB-2400M, SB-1360M, and SB-140M; SB-3670M is also discussed in the background conditions section. Minor, but significant differences in the chemical composition among the three types of pore-water samples were noted. Chemical constituents for pore-water samples are summarized in table 5 and complete analyses are reported in appendix 7.

Field Parameters and Major Inorganic Constituents

The pH and specific conductance were measured only on the in situ and equilibrated samples. The pore waters for all sites on Schoolhouse Brook including background site SB-3670M were near neutral with pH ranging from 7.4 to 7.8 (fig. 5). In contrast to the specific conductance of the surface waters, which did not vary significantly downstream, the specific conductance of the in situ pore waters increased significantly from 251 µS/cm at SB-3670M to 347 µS/cm at SB-2400M downstream of the confluence with Ely Brook and then decreased to 218 µS/cm at SB-1360M and 260 µS/cm at SB-140M (fig. 5). The specific conductance of the equilibrated pore waters did not increase significantly downstream of the Ely Brook confluence. The specific conductance of all equilibrated pore waters was considerably higher (523 to 563 µS/cm) when compared to that of the in situ pore waters (218 to 347 µS/cm); the in situ pore-water values were slightly higher or comparable to those of the surface waters.

Calcium was the dominant dissolved cation, and K, Mg, Na, and SiO_2 occur in subequal proportions, similar to the surface-water samples. The concentrations of these constituents were generally higher downstream of the confluence with Ely Brook compared to the upstream site SB-3670M. The concentrations of dissolved major cations were usually highest in the equilibrated samples (Ca: 92.1 to 104 mg/L; Mg: 4.3 to 5.7 mg/L; Na: 6.3 to 15.3 mg/L; K: 5.0 to 7.4 mg/L; SiO_2: 11.8 to 16.5 mg/L), and lowest in the in situ samples (Ca: 34.6 to 46.6 mg/L; Mg: 1.9 to 3.2 mg/L; Na: 3.8 to 16.2 mg/L; K: 2.5 to 4.1 mg/L; SiO_2: 7.6 to 10.3 mg/L). Alkalinity was the dominant anionic species and like the major cations was found in higher concentrations in the equilibrated samples (173 to 284 mg/L $CaCO_3$) than in the in situ samples (92 to 126 mg/L $CaCO_3$). The alkalinity values of the in situ pore waters were higher than surface waters (fig. 6). The hardness values of the pore waters follow identical trends with the highest hardness found in equilibrated pore waters, intermediate values for in situ pore waters, and the lowest values in surface waters (fig. 6). Sulfate concentrations were higher than chloride concentrations, reaching 99 and 14 mg/L, respectively.

Iron, Aluminum, and Manganese

Dissolved iron concentrations were below the detection limit of 20 µg/L for all in situ and equilibrated pore waters except in equilibrated pore water from SB-2400M (30 µg/L) (fig. 7). In contrast, the dissolved concentrations of iron in the centrifuged samples ranged from 28 to 213 µg/L; these maximum concentrations were found in SB-2400M. The concentrations of dissolved aluminum ranged from 6.1 to 15 µg/L in in situ pore waters, from 14 to 197 µg/L in the centrifuged sampled, and from 8.5 to 38.2 µg/L in the equilibrated samples. The highest dissolved aluminum was always in the centrifuged sample. Dissolved Mn concentrations were generally significantly higher than Al and Fe concentrations and reached 113 µg/L in the in situ pore waters, 209 µg/L in centrifuged pore waters, and 3,870 µg/L in equilibrated pore waters. Background site SB-3670M contained the highest manganese concentration, 3,870 µg/L. However, the concentrations of manganese in the in situ and centrifuged pore waters from SB-3670M were only 0.4 and 6.8 µg/L, respectively.

Minor and Trace Inorganic Elements

The minor and trace elements present in pore waters from Schoolhouse Brook were Ba (up to 75.7 µg/L), Cd (up to 0.4 µg/L), Co (up to 4.28 µg/L), Cu (up to 24.9 µg/L), Ni (up to 4.1 µg/L), Pb (up to 0.2 µg/L), Sb (up to 0.88 µg/L), Se (up to 1.5 µg/L), Sr (up to 457 µg/L), U (up to 1.07 µg/L), and Zn (up to 149 µg/L). The highest concentrations of these elements were generally found in the equilibrated pore waters, and the lowest concentrations were generally found in the in situ pore waters. The concentrations of Cd, Co, Cu, Se, and Zn were higher in pore waters downstream of the confluence with Ely Brook (SB-2400M) compared to upstream (SB-3670M) (fig. 7). Similar to surface waters, dissolved Ag, As, Be, Cr, Hg, Tl, and V concentrations in all pore waters were near or below their detection limits.

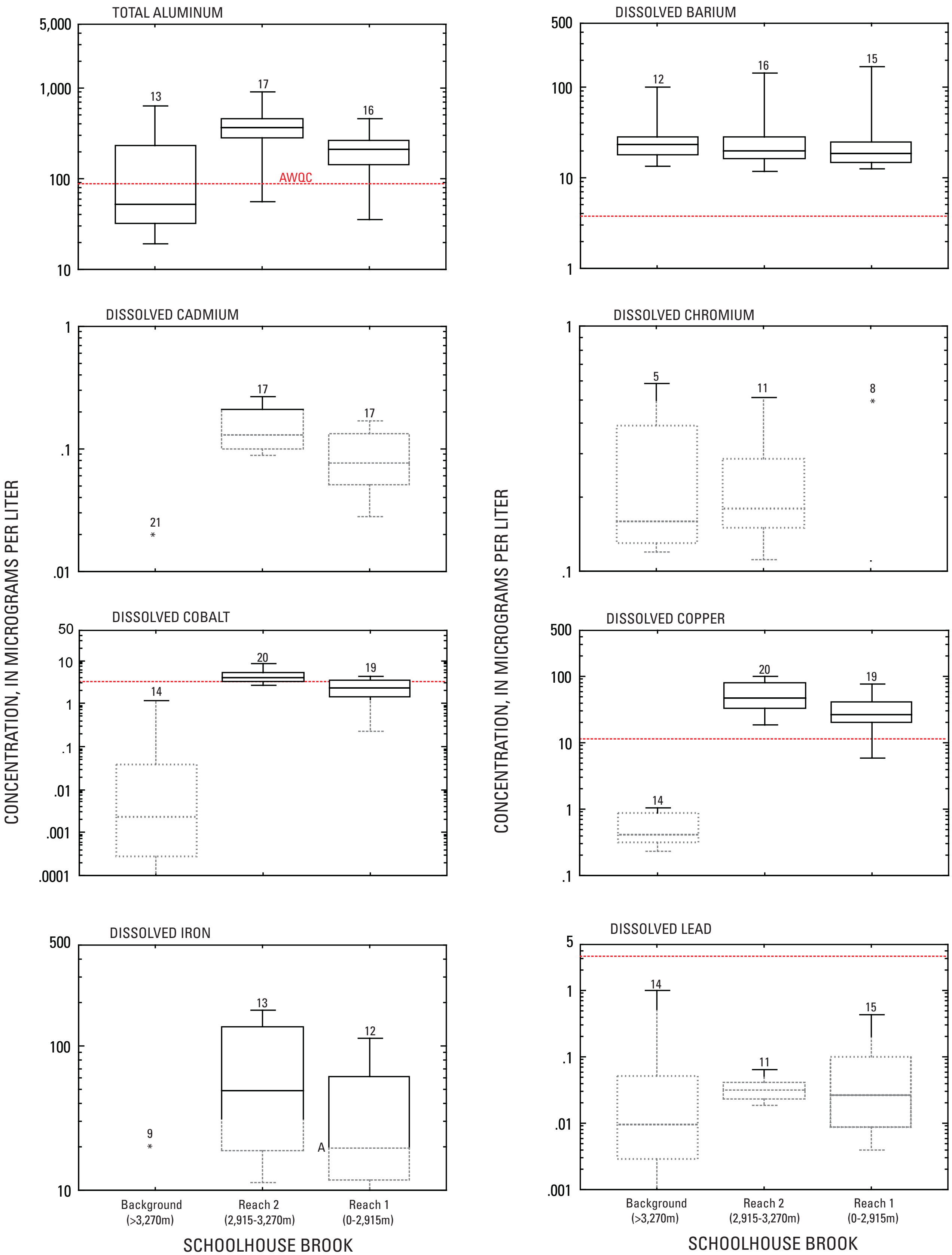


Figure 17. Select constituent concentrations in surface waters among three reaches in Schoolhouse Brook at the Ely Mine Superfund site, Vershire, VT. Data are from this study and Argue and others (2008).

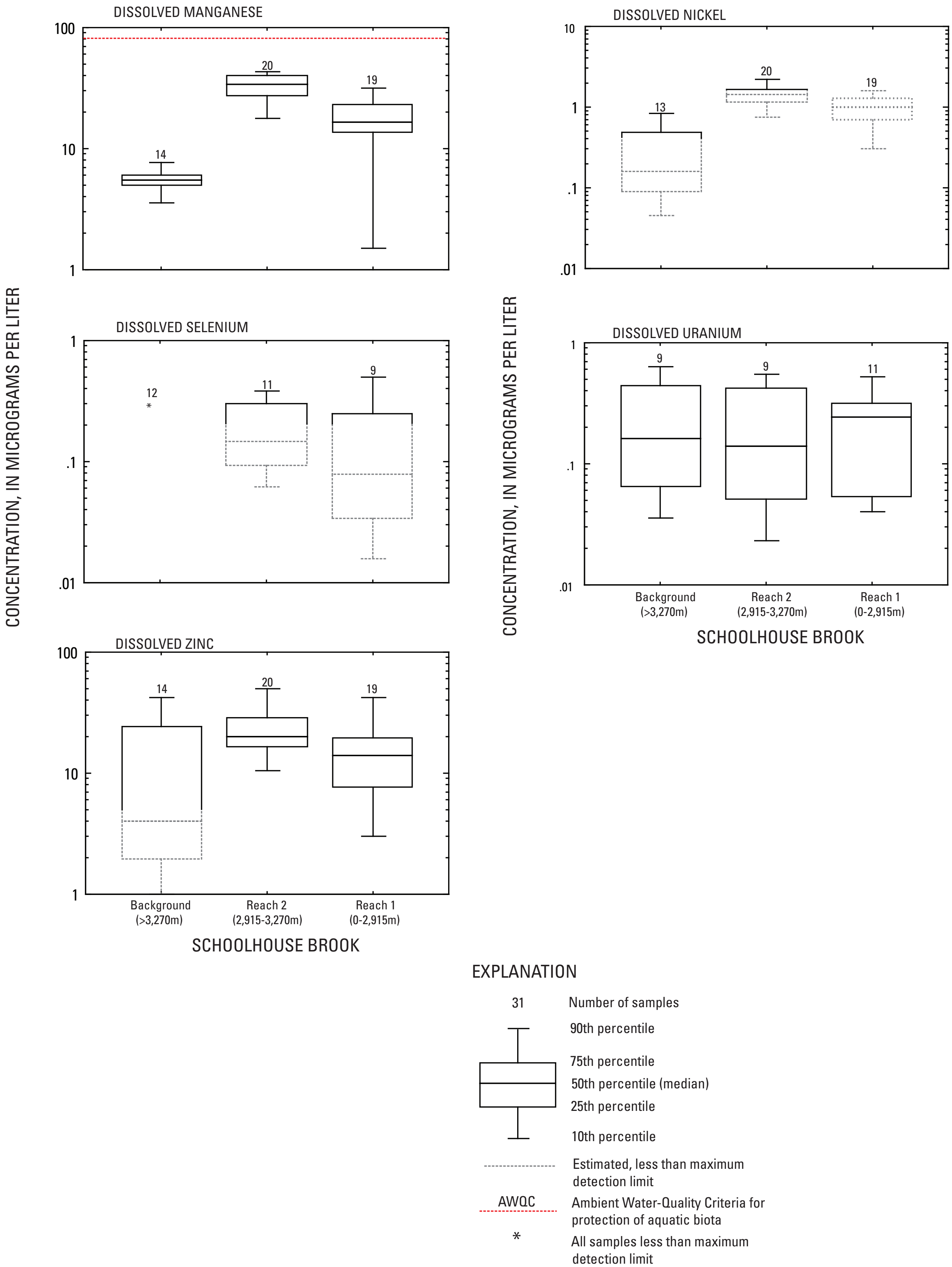


Figure 17. Select constituent concentrations in surface waters among three reaches in Schoolhouse Brook at the Ely Mine Superfund site, Vershire, VT. Data are from this study and Argue and others (2008).—Continued

Dissolved Organic Carbon and Nutrients

DOC and nutrient concentrations were determined only on samples of the in situ pore water. DOC concentrations throughout Schoolhouse Brook ranged from 0.9 to 1.6 mg/L. Nutrients were generally low throughout the brook with total dissolved nitrogen ranging from 0.07 to 0.24 mg/L and total dissolved phosphorus ranging from 0.004 to 0.006 mg/L.

Comparisons with Ambient Water-Quality Criteria

In the previous section on surface water in Schoolhouse Brook, sample sites were partitioned on the basis of stream reach and compared to ambient water-quality criteria. Hardness-dependent criteria were calculated based on the hardness of the sample. This section will refer to the same stream reaches, although pore waters are from this study, whereas surface waters included all historical samples. Pore waters were not sampled prior to this investigation. As in the previous section, stream reach 1 refers to water-quality conditions above the mouth of Schoolhouse Brook and downstream of a major tributary (SB-2400M, SB-1360M, and SB-140M); stream reach 3 refers to background conditions (SB-3670M). Pore waters were not collected in stream reach 2, which is downstream of the confluence with Ely Brook and upstream of a major tributary to Schoolhouse Brook.

The concentrations for most elements in pore waters in stream reach 3, the background site (SB-3670M), were less than AWQC with the exceptions being Al in the centrifuged split, Ba in all pore waters, and Mn in equilibrated pore water. The concentrations of Ba in all pore waters and Mn in most pore waters in stream reach 1 exceeded their AWQC of 3.8 and 80.3 µg/L, respectively. In stream reach 1, the concentrations of copper exceeded its hardness-dependent criterion in all of the equilibrated samples, most of the centrifuged samples (two of three samples), and one in situ sample. Cobalt, Al, and Zn exceeded their criteria in one to two samples for each element.

Sediment Geochemistry

The major-element geochemistry of the four sediment samples from Schoolhouse Brook (SB-3670M, SB-2400M, SB-1360M, and SB-140M) reflects their siliciclastic constituents. Chemical constituents for sediment samples are summarized in table 6, and complete analyses are reported in appendix 8. SEM-AVS data for sediment samples are summarized in table 7, and complete analyses are reported in appendix 4. Aluminum ranged from 3.1 to 3.7 weight percent, Fe from 1.39 to 2.78 weight percent, and Ca from 1.3 to 1.62 weight percent. Magnesium, K, and Na occurred in subequal proportions with concentrations that ranged from 0.6 to 0.9 weight percent. In general, the order of abundance of elements in the sediments was the following: Al > Fe > Ca > K > Na > Mg. Of these elements, only Al, Fe, and Na increased significantly downstream from the confluence with Ely Brook (SB-2400M) compared to the background sample site (SB-3670M). Also, sulfur increased from 0.03 to 0.08 weight percent downstream of the confluence with Ely Brook. Carbonate carbon was low, between 0.1 and 0.2 weight percent carbon; total organic carbon was slightly higher and ranged from 0.2 to 0.3 weight percent.

Maximum concentrations of trace elements in the Schoolhouse Brook stream sediments are 3 mg/kg for As (SB-3670M), 207 mg/kg for Ba (SB-3670M), 13.5 mg/kg for Co (SB-140M), 32 mg/kg for Cr (SB-140M), 243 mg/kg for Cu (SB-140M), 869 mg/kg for Mn (SB-140M), 2.59 mg/kg for Mo (SB-140M), 13.6 mg/kg for Ni (SB-140M), 31.4 mg/kg for Pb (SB-140M), 2.14 mg/kg for Sb (SB-140M), 1.8 mg/kg for Se (SB-2400M), 206 mg/kg for Sr (SB-1360M), and 85 mg/kg for Zn (SB-140M). The concentrations of Co, Cu, Mo, Sb, Se, and Zn increased significantly downstream from the confluence with Ely Brook (SB-2400M) in comparison to the background Schoolhouse Brook site (SB-3670M). Ag, Cd, and Hg were near or below their detection limits.

Acid volatile sulfide for the stream-sediment samples from Schoolhouse Brook were below the detection limit of 23 mg/kg (0.7 µmol/g). The sum of the concentrations of simultaneously extracted metals (Cd + Cu + Pb + Ni + Zn) was low in the background sample (SB-3670M) at 0.2 µmol/g and increased downstream of the confluence with Ely Brook to 1.3 µmol/g (SB-2400M), and then increased slightly to 1.4 and 1.6 µmol/g at SB-1360M and SB-140M, respectively. Simultaneously extracted Cd and Hg were below their detection limits.

The concentrations of As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn in the sediments from Schoolhouse Brook are below their PEC limits with the exception of Cu (table 10). The concentrations of copper in all sediments below the confluence with Ely Brook exceeded the PEC of 149 mg/kg with values that ranged from 167 to 243 mg/kg and increased with increasing distance downstream. The ΣSEM-AVS)/f_{OC} value for the background stream sediments from Schoolhouse Brook was –160 µmol/gOC, which was well within the no-effects range. In contrast, the (ΣSEM-AVS)/f_{OC} for the sediments downstream of Ely Brook ranged from 281 to 395 µmol/gOC, which falls within the uncertain effects range (USEPA, 2005).

Bioassay Results

For the Schoolhouse Brook samples, tests were conducted using *Hyalella azteca* for 28-day exposures and *Chironomus dilutus* for 12-day exposures and showed impairment downstream of the confluence with Ely Brook (table 8). For SB-3670M, the reference site, *H. azteca* had acceptable survival at 93.8 ± 4.6 percent, and growth of 3.31 ± 0.06 mm. At SB-2400M, survival dropped to 52.5 ± 7.5 percent, and growth was 2.43 ± 0.11 mm. At SB-1360M, survival rose slightly to 64.3 ± 6.1 percent, and growth was 2.53 ± 0.11 mm. The results from SB-140M, which was a field duplicate, are discussed below.

The midge (*C. dilutus*) results were somewhat different. Site SB-3670M, the reference, had unacceptable survival at 76.3 ± 5.3 percent, and growth was 1.00 ± 0.05 mm.

At SB-2400M, survival was statistically identical at 80.0 ± 4.2 percent, and growth dropped to 0.78 ± 0.04 mm. At SB-1360M, survival dropped to 62.5 ± 5.9 percent, and growth rose to 1.28 ± 0.08 mm. The results from SB-140M, which was a field duplicate, are discussed below.

Moderate differences in results of toxicity tests between field duplicate sediment samples from the downstream site on Schoolhouse Brook [SB-140M and SB-140M(D)] were found. Three of the four endpoints (amphipod survival, midge survival, and midge growth) showed differences between tests ranging from 21 to 31 percent [relative percent difference (RPD), difference expressed as percent of mean]. The fourth endpoint, amphipod growth, was nearly identical between duplicate samples (RPD = 3 percent). The observed differences were apparently not related to differences in physical or chemical constituents, which were generally within ± 10 percent for these two samples (appendixes 3 and 4). The differences in midge survival between the SB-140M duplicates were less than the range observed for this endpoint across the three reference sites, apparently reflecting the overall high variability of this endpoint in this test. In contrast, differences in amphipod survival and midge growth between SB-140M and SB-140M(D) were substantially greater than the range of these endpoints among the reference sites but were comparable to the range of responses in the non-reference sites in Schoolhouse Brook. Because all three toxicity indices indicated similar, moderate risks of toxicity across sites SB-2400M, SB-1360M, SB-140Ma, and SB-140Mb (figs. 15 and 16), the high variation of metal toxicity responses in these sediments may reflect a natural increase in variation of these responses near the threshold for toxic effects.

Relations among Trace Elements in Surface Water, Pore Water, Sediment, and Aquatic Biota

Surface water, pore water, and sediment were sampled in August 2006, and invertebrates and fish were sampled in September 2006, to relate water and sediment quality to aquatic biota. Surface water, invertebrates, and fish were sampled at SB-140M, SB-1360M, SB-2400M, SB-3100M, and SB-3670M. Pore water and sediment were sampled at SB-140M, SB-1360M, SB-2400M, and SB-3670M. Background conditions were characterized by samples obtained at SB-3670M.

HIs less than 1 were observed in water and sediments sampled at the background location (table 10). HI values for surface-water and sediment samples below the confluence with Ely Brook were greater than 1 mainly due to elevated copper concentrations (table 10). Pore-water samples below the confluence with Ely Brook, however, generally were less than 1 except for river meter 1,360, which had an HI of 1.5 due to elevated copper and zinc concentrations.

The RTH invertebrate assemblages sampled at the Schoolhouse Brook sites indicated severe impairment below the reference location SB-3670M and also that some degree of system recovery was occurring along a downstream gradient from the confluence of Ely Brook (that is, influx of contamination). The RTH assemblage data indicated that SB-3100M (below the Ely Brook confluence) was the location most severely impaired but that ecological condition of the stream had gradually improved by SB-140M (fig. 9*C*,*D*; table 9). However, the condition at SB-140M was still impaired compared to the reference location SB-3670M, where invertebrate abundance was 14 times greater and richness was more than twice as great. Comparing the RTH assemblage data to the HIs indicated that invertebrate abundance and richness were closely associated with the metal concentrations in surface water (fig. 15*C*,*D*; table 9). The HIs for sites SB-3670M and SB-3100M were the lowest and highest respectively, with little difference in HIs among SB-2400M, SB-1360M, and SB-140M. The RTH assemblage data did indicate, however, that impairment among these three sites increased with proximity to the confluence of Ely Brook; this difference in the degree of impairment is likely related to higher contaminant concentrations in surface water from Ely Brook water during storm events that are diluted farther downstream.

Compared to the RTH assemblage data, the DTH data indicated a somewhat different response along the stream gradient. Whereas the RTH data indicated impairment was greatest below the Ely Brook confluence with incremental improvement sequentially downstream (fig. 9*C*,*D*; table 9), the DTH data indicated that impairment increased to SB-1360M, with partial recovery at SB-140M (fig. 10*C*,*D*; table 9). This difference between the RTH and DTH responses can be explained by the difference in the HI values for the Schoolhouse Brook sites. The highest HI for surface water occurred at SB-3100M, where the RTH assemblage also was the most impaired (fig. 15*C*,*D*; table 9), but the highest HI for pore water occurred at SB-1360M, where the DTH assemblage was the most impaired (fig. 16*C*,*D*; table 9). Comprehensively, these results indicate that a close association exists between biological assemblages and microhabitat conditions and that characterizing this association is crucial when making ecological assessments.

The assessment of the fish assemblages in Schoolhouse Brook, based on the fish IBI scores, essentially corresponded to the extent of impairment among sites based on the RTH invertebrate assemblages; impairment was severe below the confluence with Ely Brook, but with some recovery downstream (fig. 18*A*; table 9). The association between HI values for surface water and fish assemblages also was strong (fig. 19; table 9) and was similar to the response of the RTH invertebrate assemblages (fig. 15*C*,*D*; table 9). These results also imply a relation between the invertebrate and fish assemblages, which was indicated by a strong correlation between the fish IBI scores and the invertebrate richness values for Schoolhouse Brook (rho = 0.975). However, this relation does not indicate that the fish assemblage response in Schoolhouse Brook was dependent on the RTH invertebrate response; rather, the two assemblages were likely responding similarly to levels of metal toxicity.

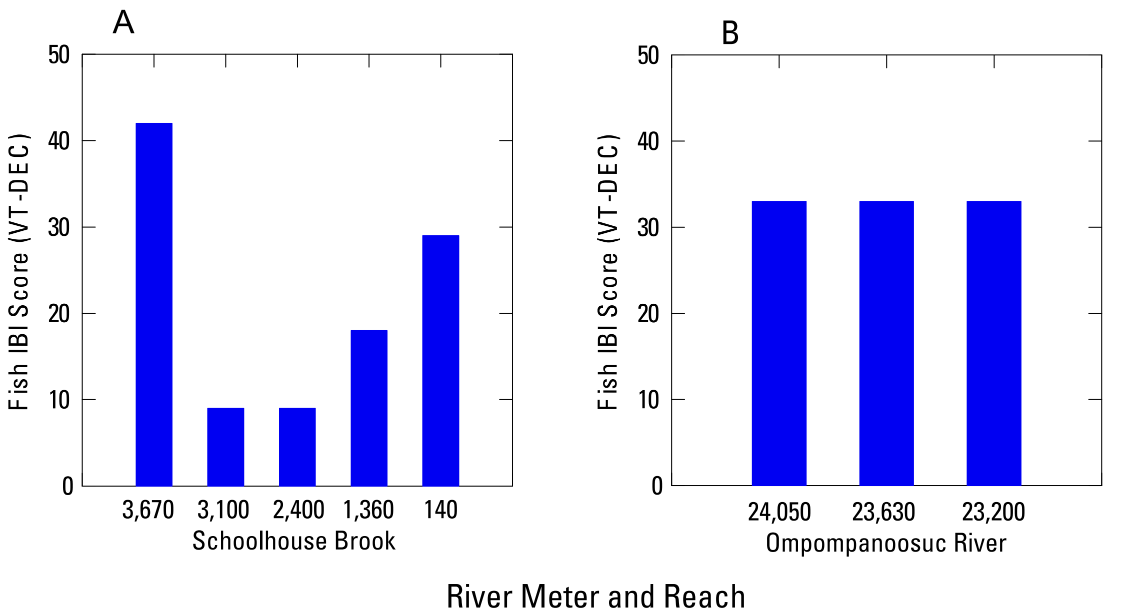


Figure 18. Fish assemblage index of biotic integrity (IBI) scores for *(A)* Schoolhouse Brook and *(B)* the Ompompanoosuc River (Vermont Department of Environmental Conservation (VT-DEC) assessment criteria). The first location in each frame was used to represent background conditions for the stream.

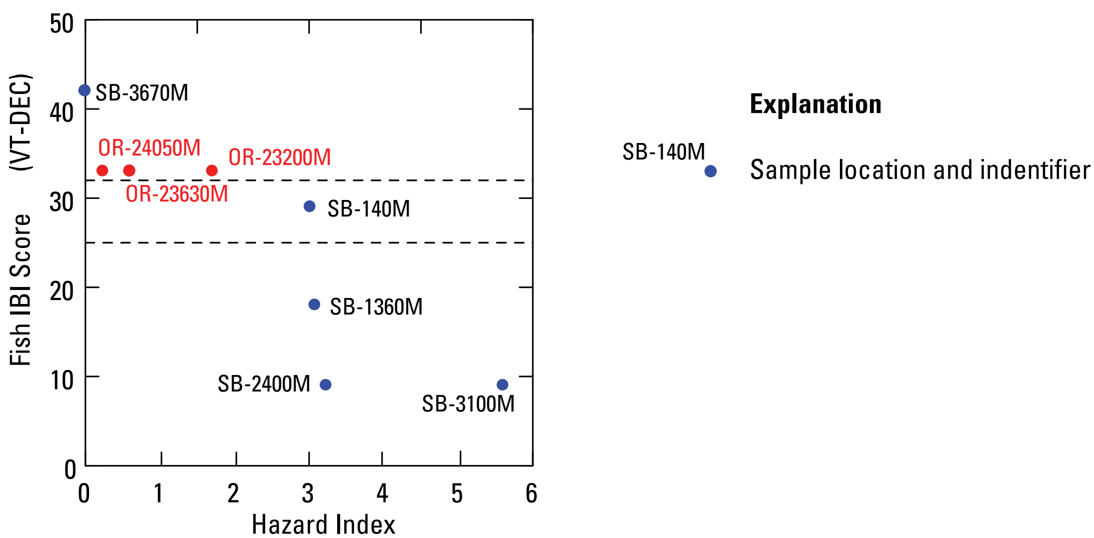


Figure 19. Fish assemblage index of biotic integrity (IBI) compared to the hazard index for surface waters. Upper dased line represents a threshold between an assessment of “Fair” and “Good”; the lower dashed line a threshold between “Fair” and Poor” (Vermont Department of Environmental Conservation (VT-DEC) assessment criteria). Blue symbols represent Schoolhouse Brook, and red symbols represent the Ompompanoosuc River.

Analysis of the fish tissue data indicates that only copper and zinc were metals of potential concern when compared with the salmonid CBR values (Argue and others, 2008). The CBR value for copper was exceeded by more than three times in the single brook trout from SB-3100M (fig. 20*A*), and it is very likely that this fish had recently migrated to this location inadvertently from upstream, because no trout was captured farther downstream. Copper concentrations in the blacknose dace generally increased with distance downstream (fig. 20*B*), although fish at sites SB-3100M and SB-2400M also may have migrated from upstream. Only two blacknose dace were captured at each of these sites, and they were relatively mature fish of one size class (weight of 4.3 to 4.9 grams), whereas 41 dace were captured downstream at SB-140M and represented several size classes (average weight of 2.5 grams).

The zinc concentrations in fish tissue exceed the CBR value for that metal at all sites, and there were no discernable patterns of variance among the sites (fig. 20*C*,*D*). Although there were not enough samples for an explicit interpretation, the greater variance in Cu concentrations in both brook trout and blacknose dace suggests that Cu could be affecting fish more than Zn in Schoolhouse Brook.

Ompompanoosuc River

Surface-Water Geochemistry

Three sites were sampled in the Ompompanoosuc River in August 2006, one of which was upstream of the confluence with Schoolhouse Brook and was also discussed in the background conditions section (OR-24050M). The two other sites are site OR-23630M, located approximately 10 m downstream from the confluence with Schoolhouse Brook, and site OR-23200M, located farther downstream (approximately 440 m downstream from the confluence). Site OR-23200M is upstream of the confluence with Lake Fairlee outflow and the West Branch of the Ompompanoosuc River. Data from these sites will be used to examine downstream variations in water chemistry. Chemical constituents for surface-water samples are summarized in table 4, and complete analyses are reported in appendix 6.

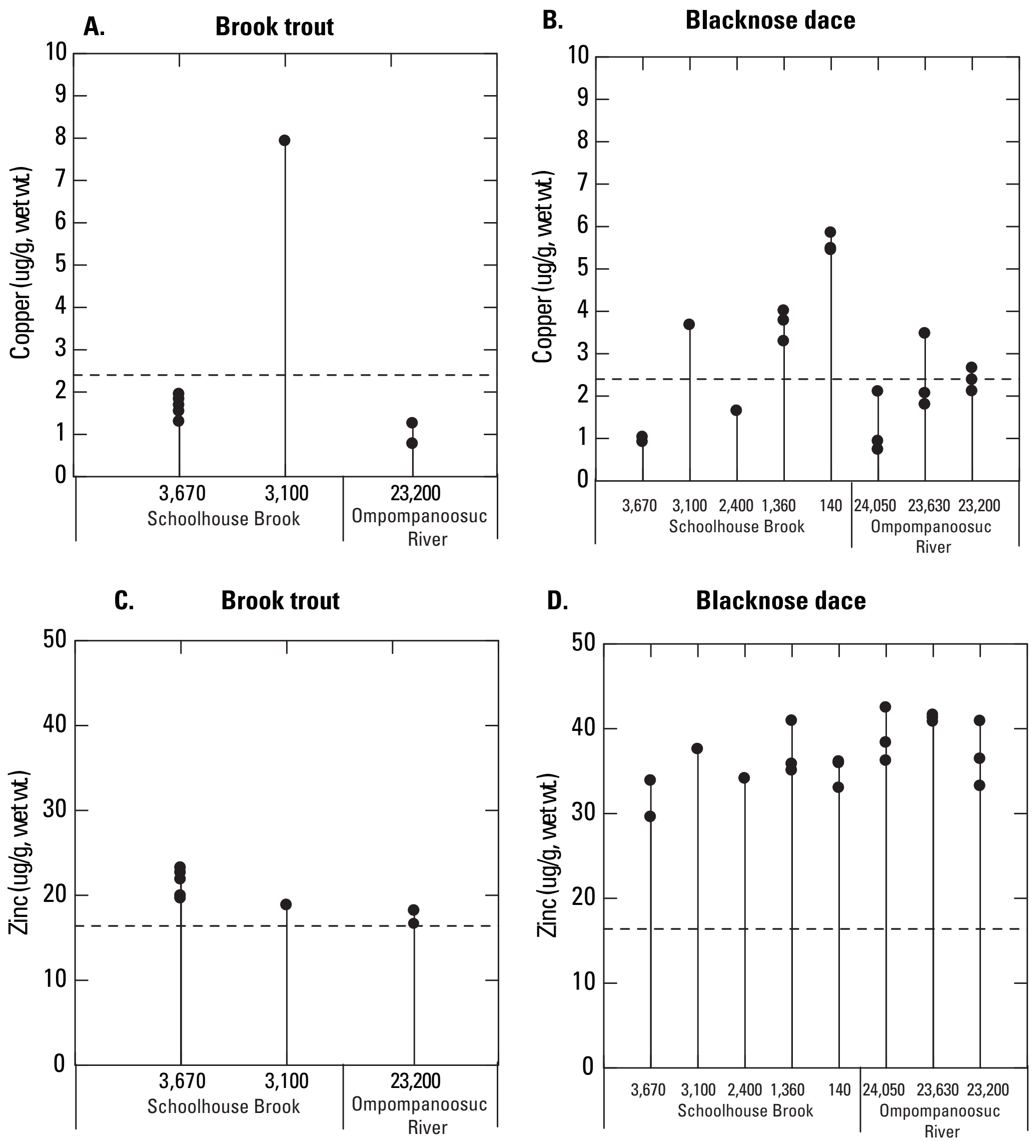


Figure 20. Concentrations of copper and zinc in brook trout and blacknose dace tissue compared to the critical body residue (CBR) values for salmonids. The CBR value for copper [2.4 micrograms per gram wet weight (µg/g, wet wt.)] is based on the effects level and for zinc (16.4 micrograms per gram wet weight) is based on the no-effects level (the effects level not reported for zinc). At each location, each dot represents a single fish sample for brook trout or a composite sample for blacknose dace.

Field Parameters and Major Inorganic Constituents

The pH and specific conductance of surface waters from the Ompompanoosuc River did not vary significantly among samples; pH ranged from 8.0 to 8.1, and specific conductance ranged from 196 to 198 µS/cm (fig. 5). The concentrations of the major dissolved cations also did not fluctuate considerably along the river reach sampled. For example, dissolved concentrations of Ca ranged from 32 to 32.9 mg/L, K ranged from 2.16 to 2.24 mg/L, Mg ranged from 1.46 to 1.61 mg/L, and Na ranged from 5.15 to 5.45 mg/L. Dissolved silica (SiO_2) only ranged from 7.2 to 7.8 mg/L, and alkalinity, the dominant anionic species, only ranged from 85 to 87 mg/L (fig. 6). Chloride and sulfate were the next most abundant anionic species with concentrations of 5.4 to 6 mg/L and 7.2 to 8 mg/L, respectively. Previous reports found similar results or contained similar data (Seal and others, 2001; Holmes and others, 2002; Argue and others, 2008).

Iron, Aluminum, and Manganese

The concentrations of dissolved aluminum and manganese increased from 13.4 to 44.6 µg/L and from 4.7 to 8.9 µg/L, respectively, from background conditions at OR-24050M to the farthest downstream site at OR-23200M (fig. 7). The increase in concentrations from OR-24050M to OR-23630M was due to mixing of waters from Schoolhouse Brook which contained higher concentrations of these elements (93.5 µg/L of Al and 13.6 µg/L of Mn at SB-140M). The concentrations of dissolved Fe are below the detection limit of 20 µg/L in all three samples.

Minor and Trace Inorganic Elements

The concentrations of several minor and trace elements, although generally low, increased from the background site of OR-24050M to the farthest downstream site of OR-23200M (fig. 7). These elements include Cd (<0.02 to 0.1 µg/L), Co (<0.02 to 0.31 µg/L), Cu (0.84 to 8.9 µg/L), and Pb (0.08 to 0.2 µg/L). The concentrations of dissolved zinc increased from 9.3 µg/L (OR-24050M) to 12.5 µg/L (OR-23630M) and then decreased to 6.9 µg/L (OR-23200M). The concentrations of Ba (19.1 to 20.2 µg/L), Sr (138 to 139 µg/L), and U (0.24 µg/L) did not vary significantly among samples. Dissolved Ag, As, Be, Cr, Hg, Sb, Se, Tl, and V concentrations were all below their detection limits. Concentrations of dissolved nickel were near or below its detection limit.

Dissolved Organic Carbon and Nutrients

DOC concentrations throughout the Ompompanoosuc River were nearly constant (2.5 to 2.6 mg/L) and slightly higher than that of Schoolhouse Brook. Nutrients were generally low throughout the study area. Total dissolved nitrogen was 0.2 mg/L, and total dissolved phosphorus ranged from 0.005 to 0.007 mg/L.

Trace-Element Loads

Coupled streamflow measurements and surface-water samples obtained at OR-23200M, OR-23630M, and OR-24050M on August 21, 2006, were used to describe the attenuation of constituents in the Ompompanoosuc River. Background conditions were characterized by samples obtained at OR-24050M.

Most constituent loads at OR-23630M were similar to those expected from a summation of loads for SB-140M and OR-24050M (fig. 13). However, loads for total Al, Co, Cu, and Fe and dissolved Co and Cu at OR-23630M were less than expected assuming simple mixing. This is most likely the result of Fe hydroxides settling to the river bottom as waters travel from the steep gradient of Schoolhouse Brook to the more tranquil Ompompanoosuc River, as reflected by the higher Fe concentrations in the Ompompanoosuc sediments downstream of the confluence with Schoolhouse Brook (table 6).

Iron and manganese oxidation in the surface water and reductive dissolution in the hyporheic zone of the streambed are most likely driving the fate and transport of constituents in the Ompompanoosuc River from OR-23630M to OR-23200M. AVS was not detected in the streambed sediments, and sulfate loads were similar between locations. Loads for total and dissolved Cd, Co, Cu, total Fe, and dissolved Mn increased, and loads for total Mn decreased from OR-23630M to OR-23200M. Transient flow through the streambed may induce cycling of Fe and Mn hydroxides and the release of associated metals as O_2 or NO_3 infiltrates to reduced sections of the hyporheic zone (Koretsky and others, 2006). This also may be evident as manganese concentrations in the pore water were elevated, as is typical at the boundary of the anoxic layer (Koretsky and others, 2006). Transient flow through the streambed that diffuses upward most likely results in reprecipitation of Fe and Mn hydroxides, whereas flow diffusing downward to more reduced sediments most likely results in Fe being associated with the sulfides and Mn being associated with carbonates (Koretsky and others, 2006).

Comparisons with Ambient Water-Quality Criteria and Relations among Reaches

The Ompompanoosuc River was partitioned into three reaches for analysis of water data on the basis of the proximity to runoff associated with the Ely Mine site and the confluence with a tributary. Stream reach 1, defined by locations sampled from river meter 8,350 to 20,000, is a fourth-order stream reach (table 2) and was partitioned to describe water-quality conditions above the confluence with the West Branch Ompompanoosuc River and below the confluence with the Lake Fairlee outflow tributary. Stream reach 2, defined by locations sampled from river meter 20,000 to 23,640, is a third-order stream reach and was partitioned to describe water-quality conditions downstream of the confluence with Schoolhouse Brook and above the Lake Fairlee outflow tributary. Stream reach 3, defined by locations sampled above river meter 23,640, was partitioned to describe background conditions.

Concentrations in surface waters greater than AWQC were observed in stream reach 1 for Al, Ba, Mn, and Ag, and in stream reach 2 for Al, Ba, Cu, and Hg (fig. 21, appendix 5). Concentrations of most elements in surface waters of reaches 1 and 2 generally were similar to background conditions (rho > 0.05). However, concentrations of Co, Cu, and Mn in reach 1 and Cd, Co, and Cu in reach 2 generally were greater than and significantly different from background conditions (rho < 0.05). Concentrations of Co and Cu in reach 1 generally were less than and significantly different from those observed in reach 2 (rho < 0.05).

Pore-Water Geochemistry

Pore-water samples from the Ompompanoosuc River were collected from the background conditions site OR-24050M and farthest downstream site OR-23200M. Pore water was not collected at OR-23630M, which was 10 m downstream of the confluence with Schoolhouse Brook. Chemical constituents for pore-water samples are summarized in table 5, and complete analyses are reported in appendix 7.

Field Parameters and Major Inorganic Constituents

The pH and specific conductance were measured only on the in situ and equilibrated samples. The pH of pore waters from the Ompompanoosuc River was near neutral and ranged from 7.4 to 7.9 (fig. 5). This is comparable to the pH of the pore waters from Schoolhouse Brook upstream from its mouth (SB-140M). The differences in pH between the in situ and equilibrated pore waters were not significant. In contrast to pH, the specific conductance values of the equilibrated pore water (535 to 709 µS/cm) were significantly higher than the in situ splits (277 to 359 µS/cm), which were higher than surface-water values (196 to 198 µS/cm) (fig. 5).

Calcium was the dominant dissolved cation, and K, Mg, Na, and SiO_2 occurred in subequal proportions, similar to the surface-water samples. The concentrations of most of these constituents were lower in pore waters from the site downstream of the confluence with Schoolhouse Brook (OR-23200M) compared to the upstream background site (OR-24050M). The concentrations of dissolved major cations were usually highest in the equilibrated samples and lowest in the in situ samples, with the intermediate concentrations in centrifuged splits (table 5). Dissolved cation concentrations reached 137 mg/L for Ca, 12.9 mg/L for K, 7.78 mg/L for Mg, 16.8 mg/L for Na, and 16.1 mg/L for SiO_2. Hardness ranged from 95.5 to 141.3 mg/L $CaCO_3$ equivalent in the in situ samples, from 186.6 to 187.9 mg/L in centrifuged samples, and from 233.6 to 374.4 mg/L in equilibrated samples. Alkalinity was the dominant anionic species; sulfate and chloride concentrations were significantly less and occurred in subequal proportions (fig. 6).

Iron, Aluminum, and Manganese

Dissolved iron concentrations were below the detection limit of 20 µg/L for in situ and equilibrated pore waters; the concentrations in the centrifuged samples were 30 and 23 µg/L for OR-24050M and OR-23200M, respectively (fig. 7). The concentrations of dissolved aluminum were also low and reached 38.5 µg/L in the centrifuged pore water from site OR-23200M. Dissolved Mn concentrations were significantly higher than Al and Fe concentrations and reached 327 µg/L in the in situ pore waters, 1,500 µg/L in centrifuged pore waters, and 6,270 µg/L in equilibrated pore waters. Aluminum and manganese were not determined on centrifuged pore waters due to insufficient sample size.

Minor and Trace Inorganic Elements

The minor and trace elements present in pore waters from the Ompompanoosuc River were Ba (up to 126 µg/L), Cd (up to 0.19 µg/L), Co (up to 3.08 µg/L), Cr (up to 1.9 µg/L), Cu (up to 19.1 µg/L), Ni (up to 3.8 µg/L), Pb (up to 0.3 µg/L), Se (up to 1.2 µg/L), Sr (up to 559 µg/L), U (up to 1.91 µg/L), V (up to 1.8 µg/L), and Zn (up to 5.7 µg/L). The highest concentrations of these elements were commonly found in the equilibrated pore waters, and the lowest concentrations were commonly found in the in situ pore waters. The concentrations of Cd, Co, Cu, and Pb were higher in pore waters downstream of the confluence with Schoolhouse Brook (OR-23200M) compared to upstream (OR-24050M) (fig. 7). Similar to surface waters, dissolved Ag, As, Be, Hg, Sb, and Tl concentrations in all pore waters were below their detection limits.

Dissolved Organic Carbon and Nutrients

DOC and nutrient concentrations were determined only on splits of the in situ pore-water samples. DOC concentrations were 1.4 mg/L in both OR-24050M and OR-23200M pore waters. Nutrients were low, with total dissolved nitrogen values of 1.04 mg/L for OR-24050M and 0.2 mg/L for OR-23200M, and total dissolved phosphorus of 0.006 mg/L for OR-24050M and 0.005 mg/L for OR-23200M.

Comparisons with Ambient Water Quality Criteria

In the previous section on surface water in the Ompompanoosuc River, sample sites were divided on the basis of stream reach and compared to ambient water-quality criteria. Hardness-dependent criteria were calculated based on the hardness of the sample. This section will refer to the same stream reaches although pore waters are from this study whereas surface waters included all historical samples. Pore waters were not sampled prior to this investigation. As in the previous section, stream reach 2 refers to water-quality conditions downstream from the confluence with Schoolhouse Brook and upstream from the confluence with Lake Fairlee outflow; OR-23200M is from this reach. Stream reach 3 refers to water-quality conditions upstream of the confluence with Schoolhouse Brook and represents background concentrations;

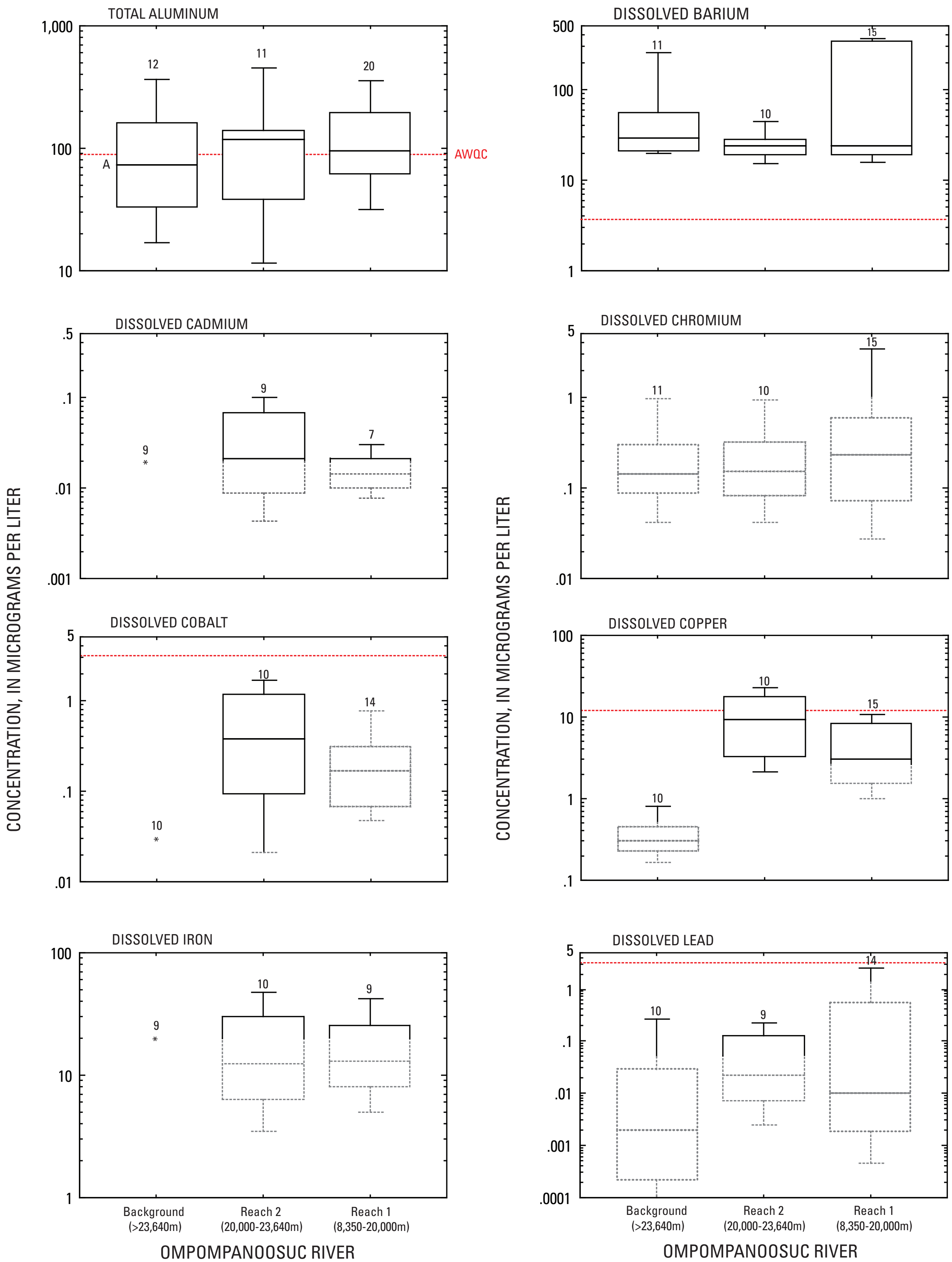


Figure 21. Select constituent concentrations in surface waters among three reaches in the Ompompanoosuc River at the Ely Mine Superfund site, Vershire, VT. Data are from this study and Argue and others (2008).

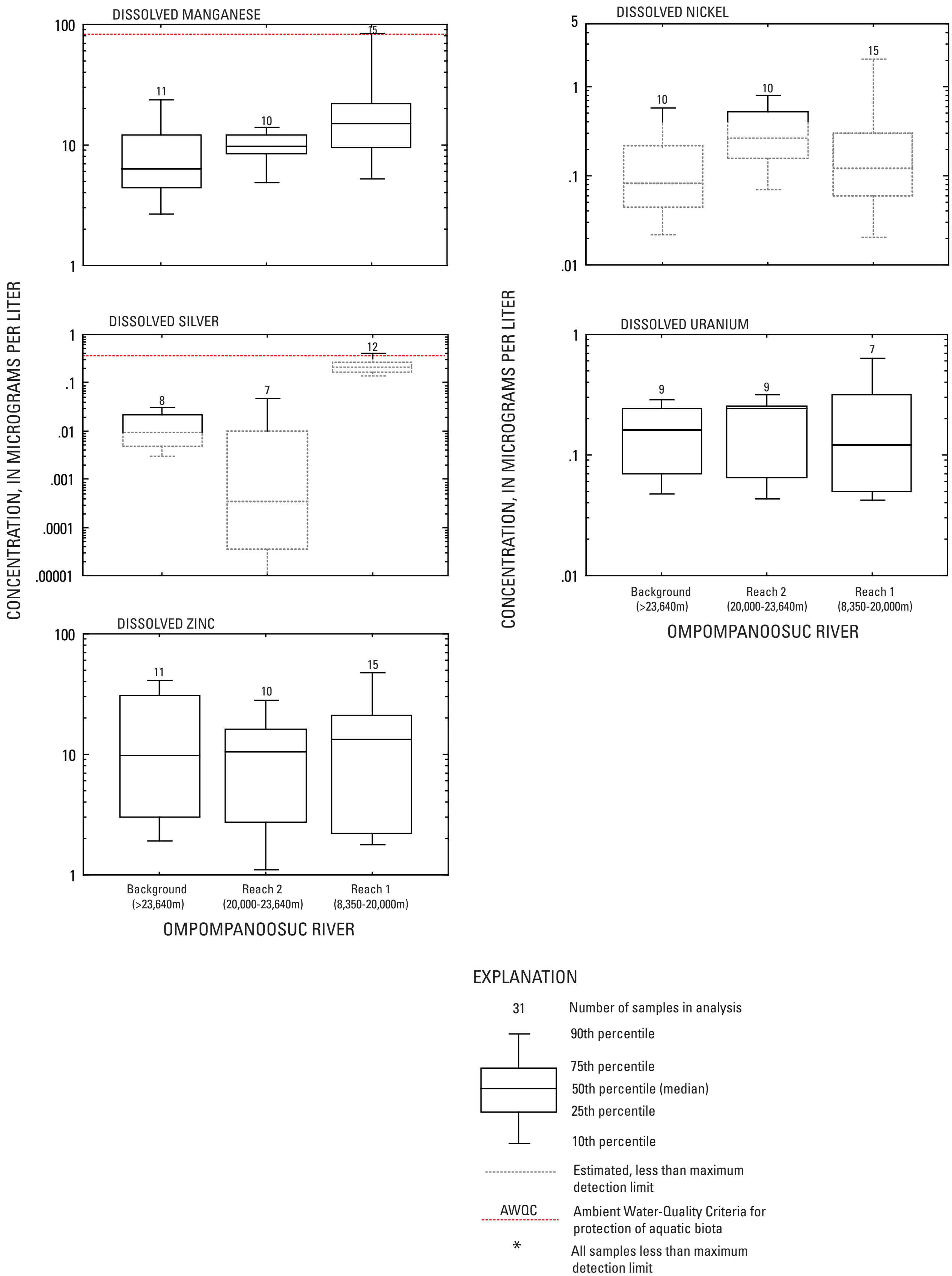


Figure 21. Select constituent concentrations in surface waters among three reaches in the Ompompanoosuc River at the Ely Mine Superfund site, Vershire, VT. Data are from this study and Argue and others (2008).—Continued

OR-24050M is from this reach. Pore waters were not collected in stream reach 1, which is downstream of the confluence with Lake Fairlee outflow and upstream of the confluence with the West Branch of the Ompompanoosuc River.

The concentrations of barium and manganese in pore waters in stream reaches 2 and 3 exceeded the AWQC of 3.8 and 80.3 µg/L, respectively. Uranium is the only other element in the background conditions sample (reach 3) which exceeded (only minimally) its water-quality criteria of 1.87 µg/L; the concentrations of uranium in the equilibrated pore water was 1.91 µg/L. Similar to uranium, the concentration of dissolved cobalt in the centrifuged pore water barely exceeded its AWQC of 3.06 µg/L with a concentration of 3.08 µg/L. The only other elemental exceedance was Cu in the equilibrated pore water of sample OR-23200M with a concentration of 19.1 µg/L.

Sediment Geochemistry

Sediment samples from the Ompompanoosuc River were collected from the background conditions site OR-24050M and farthest downstream site OR-23200M. The major-element geochemistry of the sediment samples reflects their siliciclastic constituents. Chemical constituents for sediment samples are summarized in table 6, and complete analyses are reported in appendix 8. SEM-AVS data for sediment samples are summarized in table 7, and complete analyses are reported in appendix 4. Aluminum ranged from 3.27 to 3.54 weight percent, Fe from 1.4 to 2.28 weight percent, and Ca from 1.13 to 1.3 weight percent. Mg, K, and Na occurred in subequal proportions with concentrations that ranged from 0.71 to 0.84 weight percent. In general, the order of abundance of elements in the sediments was the following: Al > Fe > Ca > K > Na > Mg. Of these elements, only Al, Fe, and Ca increased significantly downstream from the confluence with Schoolhouse Brook (SB-2400M) compared to the background sample site (OR-24050). Sulfur did not vary significantly and ranged from 0.02 to 0.03 weight percent. Carbonate carbon was low (0.04 to 0.05 weight percent C), and total organic carbon was considerably higher in comparison (0.25 to 0.37 weight percent).

Maximum concentrations of trace elements in the Ompompanoosuc River sediments are 5 mg/kg for As (OR-23200M), 195 mg/kg Ba (OR-23200M), 8.1 mg/kg Co (OR-23200M), 37 mg/kg Cr (OR-24050M), 76.7 mg/kg Cu (OR-23200M), 1,120 mg/kg Mn (OR-23200M), 0.5 mg/kg Mo (OR-23200M), 11.7 mg/kg Ni (OR-24050M), 10.4 mg/kg Pb (OR-23200M), 0.22 mg/kg Sb (OR-23200M), 198 mg/kg Sr (OR-24050M), and 53 mg/kg Zn (OR-23200M). The concentrations of Co, Cu, Mn, Mo, and Zn were significantly higher in the downstream sediment sample (OR-23200M) compared to the background sample site (OR-24050M). Ag, Cd, Hg, and Se were near or below their detection limits.

Acid volatile sulfide for the stream-sediment samples from the Ompompanoosuc River was below the detection limit of 23 mg/kg (0.7 µmol/g). The sum of the concentrations of simultaneously extracted metals (Cd + Cu + Pb + Ni + Zn) were low with 0.2 µmol/g for sediment from the background site (OR-24050M) and 0.4 µmol/g for the downstream site (OR-23200M). Simultaneously extracted Cd and Hg were below their detection limits.

The concentrations of As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn in the sediments from Ompompanoosuc River are below the PEC limits. The ΣSEM-AVS)/f_{OC} values for the sediments were –140 (OR-24050M) and –95 (OR-23200M) µmoles/gOC, which were well within the no-effects range (USEPA, 2005).

Bioassay Results

For the Ompompanoosuc River samples, tests showed no impairment downstream of the confluence with Schoolhouse Brook (table 8). For OR-24050M, the reference site, *H. azteca* had acceptable survival at 93.8 ± 6.5 percent, and growth of 3.21 ± 0.02 mm. At OR-23200M, survival was 91.3 ± 3.0 percent, and growth was 3.17 ± 0.01 mm. The midge (*C. dilutus*) results were similar. Site OR-24050M, the reference, had acceptable survival at 90.0 ± 1.9 percent, and growth was 1.06 ± 0.08 mm. At OR-23200M, survival was 83.8 ± 6.0 percent, and growth was 0.96 ± 0.14 mm.

Relations among Trace Elements in Surface Water, Pore Water, Sediment, and Aquatic Biota

Surface water, pore water, and sediment were sampled in August 2006, and invertebrates and fish were sampled in September 2006 to relate water and sediment conditions to aquatic biota. Surface water, invertebrates, and fish were sampled at OR-23200M, OR-23630M, and OR-24050M. Pore-water and sediment samples were obtained at OR-23200M and OR-24050M. Background conditions were characterized by samples obtained at OR-24050M.

HIs less than 1 were observed for all water and sediments sampled except for the surface waters sampled at OR-23200M, which had a HI of 1.7 (table 10). An HQ value of 0.1 was observed for Cu in surface water at OR-23200M.

The RTH and DTH invertebrate data indicated that there may be some impairment to the Ompompanoosuc River caused by acid-rock drainage coming from Schoolhouse Brook. From sites OR-24050M to OR-23200M, RTH abundance declined by 33 percent, and richness declined by 40 percent (fig. 9*E*,*F*). No DTH sample was collected at the OR-23630M location, but comparing OR-24050M with OR-23200M indicated that invertebrate abundance decreased by 58 percent and richness decreased by 19 percent (fig. 10*E*,*F*). Both the RTH and DTH responses were associated with increases in the HIs for surface water (fig. 15*E*,*F*; table 9) and pore water (fig. 16*E*,*F*; table 9), respectively, although the only HI to exceed 1.0 was at OR-23200M (HI = 1.7). Compared to the RTH assemblages, the relatively less impairment in the DTH assemblages from OR-24050M to OR-23200M could perhaps be associated by the low HI for pore water at OR-23200M (HI = 0.9). Even the sediments at OR-23200M were relatively uncontaminated (HI = 0.9); among all the non-reference sites sampled for pore water or sediment in the study, the respective HIs at OR-23200M were the lowest.

The assessment of the fish assemblages in Ompompanoosuc River did not clearly indicate that any degree of impairment was caused by acid-mine drainage from Schoolhouse Brook. The IBI value derived for the assemblages at all three sites was 33 (fig. 18*B*; table 9), which was the minimal score for a bioassessment classification of “good” by the VTDEC (2008). The assessment at OR-23200M was based on data from the survey that was conducted in 2007. Based on the fish assemblage data from the original 2006 survey, the OR-23200M was assessed as “poor,” but of the eight metrics used to derive the fish IBI, only density of individuals failed. The fish resurvey was done 1 year later (within 1 day), and the number of fish captured was exactly twice the number from the original survey (124 and 62, respectively). In comparing the fish IBI values with surface-water HIs among all locations, the Ompompanoosuc locations were between SB-3670M (HI = 0, IBI = 42) and SB-140M (HI = 3.0, IBI = 29), as might be predicted (fig. 19).

Only two brook trout were captured on the Ompompanoosuc River for a tissue sample, and both were at location OR-23200M. Both samples of trout had Cu concentrations below the Cu CBR value and had Zn concentrations only slightly above the Zn CBR value (fig. 20*A*,*C*). However, the zinc concentrations were still less than zinc values in the five fish from the reference location (SB-3670M). The concentrations of Cu in blacknose dace increased somewhat in the Ompompanoosuc River below Schoolhouse Brook, as based on the average concentration in the three composite samples from each location. The average concentration was 1.3 mg/kg at OR-24050M and 2.4 mg/kg at both OR-23630M and OR-23200M; however, even these averages were only equal to the CBR value for copper (fig. 20*B*). As seen in the Schoolhouse Brook sites, concentrations of zinc in blacknose dace showed no discernible pattern among the Ompanoosuc River sites, even though all samples were well above the CBR level for Zn (fig. 20*D*).

Discussion

The health of the aquatic ecosystem surrounding the Ely Mine Superfund site has been assessed by investigating ecological indicators of aquatic ecosystem health and then by examining geochemical attributes of associated water and sediments to explain the biological observations. Ecological indicators used in this study include parameters for both invertebrates and fish. Invertebrate measures include infauna and epifauna invertebrate assemblage abundance and richness data. The fish community was assessed using an index of biotic integrity.

Several approaches are available to evaluate the potential toxicity of both the surface water and sediment. Surface-water toxicity can be evaluated on the basis of hardness-based criterion maximum concentration (CMC) values for acute toxicity and criterion continuous concentration (CCC) values of Ag, Cd, Cu, Cr(III), Ni, Pb, and Zn (USEPA, 2006). Copper toxicity can also be evaluated on the basis of a water-quality criterion that incorporates the role of DOC through the Biotic Ligand Model (USEPA, 2007). Sediment toxicity can be evaluated through comparison of concentrations of As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn with a probable effects concentration (PEC; MacDonald and others, 2000). It can also be evaluated in terms of an equilibrium-partitioning sediment benchmark (ESB; USEPA, 2005) that combines Cd, Cu, Ni, Pb, and Zn. Sediment toxicity can be evaluated additionally using pore-water concentrations relative to water-quality standards. This study used three separate approaches to investigate pore-water compositions. Sediment toxicity has also been assessed in this study through toxicity testing employing *Hyalella azteca* with 28-day exposures and *Chironomus dilutus* with 10-day exposures.

Surface-Water Quality

Surface-water chemistry throughout the site was dominated by streams of moderate alkalinity and hardness that become impacted from the influx of acid-mine drainage in and around the mine-waste piles, which was then followed by progressive dilution by larger streams of moderate alkalinity and hardness downstream of the site. Surface water in Ely Brook and tributary 2 in Ely pond 1 started with neutral pH (7.0 to 7.2), low specific conductance (51 to 87 µS/cm), low hardness (18.8 to 38.3 mg/L $CaCO_3$), moderate alkalinity (19 to 41 mg/L $CaCO_3$ equivalent), and low DOC (1.9 to 3.5 mg/L). Ely Brook showed only modest variations in pH and increases in specific conductance from EB-1080M to EB-600M prior to reaching the area of the mine-waste piles and before its confluence with tributary 2, which drains the ponds. Through this same reach, alkalinity decreased from 41 mg/L $CaCO_3$ to 0, dissolved sulfate concentrations increased modestly up to 52 mg/L, dissolved Fe was near the detection limit (20 µg/L), dissolved Al reached 25.1 µg/L, dissolved Cd reached 1.0 µg/L, dissolved Cu reached 837 µg/L, and dissolved Zn reached 114 µg/L.

Tributary 2 underwent significant changes in water chemistry prior to merging with Ely Brook, with the most dramatic changes taking place between Ely ponds 4 and 5. The pH dropped from 7.0 to 6.5 in pond 5 and to 4.7 in Ely pond 6. Likewise, the specific conductance increased from 51 to 117 µS/cm in pond 5 to 206 µS/cm in pond 6. Through this same reach, alkalinity reached a high of 31 mg/L $CaCO_3$ but decreased to 17 mg/L and then 0, hardness increased to 63.6 mg/L $CaCO_3$, dissolved sulfate concentrations increased from 6.3 mg/L in pond 1 to 33 mg/L in pond 5 and 93 mg/L in Ely pond 6. Dissolved iron and aluminum concentrations were less systematic. The dissolved iron concentration in the reference pond was 66 µg/L, reached 353 µg/L in pond 2, dropped to <20 µg/L in pond 5 before reaching a maximum of

565 µg/L in pond 6. In contrast, the dissolved aluminum concentration in pond 1 was 15.8 µg/L, then fluctuated between 5.5 and 10.1 µg/L in ponds 2 through 5 before reaching a maximum of 1,410 µg/L in pond 6. Trace metals showed a more systematic variation with dissolved Cd going from less than detection (<0.02 µg/L) in the reference pond to 2.3 µg/L in pond 6, dissolved Cu from 1.1 µg/L in the reference pond to to 1,380 µg/L in pond 6, and dissolved Zn from 2.3 µg/L in the reference pond to 325 µg/L in pond 6. For all three trace metals, the dissolved concentrations increased by a factor of 2 to 3 going from pond 5 to 6. In April 2002, Holmes and others (2002) sampled tributary 2 downstream of the ponds prior to the confluence with Ely Brook (their site EB3) on two separate occasions. They found that pH ranged between 3.3 and 4.3, hardness between 33 and 34 mg/L $CaCO_3$ equivalent, and dissolved sulfate between 66 and 74 mg/L. Dissolved Fe concentrations ranged from 4,300 to 4,600 µg/L, dissolved Al from 2,500 to 3,600 µg/L, dissolved Cd from 1.9 to 2.4 µg/L, dissolved Cu from 1,400 to 2,000 µg/L, and dissolved Zn from 260 to 310 µg/L.

Prior to entering Schoolhouse Brook, Ely Brook (EB-90M) had low pH (3.2), high specific conductance (447 µS/cm), moderate hardness (75.5 mg/L $CaCO_3$), no alkalinity, and low DOC (1.6 mg/L). Dissolved Fe (6,370 µg/L), Al (4,190 µg/L), Cd (2.0 µg/L), Cu (1,560 µg/L), and Zn (373 µg/L) concentrations were high.

Upon entering Schoolhouse Brook, the effluent from Ely Brook was diluted rapidly. Ely Brook only contributes approximately 7 percent of the flow to Schoolhouse Brook immediately downstream of their confluence on the basis of their drainage areas (table 2). Relative to sites EB-90M in Ely Brook and SB-3125M in Schoolhouse Brook downstream of the confluence in August 2006, dilution of Ely Brook resulted in an increase in pH from 3.2 to 7.8, a decrease in specific conductance from 447 to 215 µS/cm, and an increase in hardness from 75.5 to 95.9 mg/L $CaCO_3$. The DOC concentration was essentially unchanged (1.6 mg/L at EB-90M and 1.3 mg/L at SB-3125M). Dissolved constituents that could be attributed to mine drainage from Ely Brook include sulfate, which decreased from 143 to 13 mg/L, 9 percent of its orginal concentration; dissolved Fe, which dropped from 6,370 to 49 µg/L, less than 1 percent of its original concentration; dissolved Al, which dropped from 4,790 to 109 µg/L, 2.3 percent of its original concentration; Cu, which dropped from 1,780 to 44 µg/L, 2.4 percent of its original concentration; and Zn, which dropped from 357 to less than 20 µg/L, less than 6 percent of its original concentration. The drop in sulfate concentration was consistent with dilution considering its conservative behavior in solution; however, the magnitudes of decreases in Al, Fe, Cu, and Zn indicated that the concentrations of these elements were additionally reduced by precipitation of Fe and Al hydroxides and sorption of Cu and Zn onto these substrates.

With increasing distance downstream in Schoolhouse Brook and then the Ompompanoosuc River, contamination from the site becomes increasingly diluted. Despite decreasing concentrations for mine-drainage constituents, the dissolved and total loads of most metals remained fairly constant from Ely Brook downstream to the Ompompanoosuc River (fig. 13). At OR-23200M, the water quality was virtually indistinguishable from background conditions with the exception of slightly elevated dissolved concentrations of aluminum (44.6 µg/L) and copper (8.9 µg/L). In addition to dilution, precipitation of Fe and Al hydroxides and sorption onto these substrates are also important controls on the concentrations of Fe, Al, and trace metals in solution.

With regards to chronic toxicity for aquatic ecosystems, only five elements exceeded water-quality standards locally: Fe, Al, Cd, Cu, and Zn. Iron and Al have fixed standards, but those for Cd, Cu, and Zn are a function of water chemistry (USEPA, 2006, 2007). The hardness used to calculate the various water-quality standards was that of the sample rather than average values used for the whole site. Iron only exceeded chronic standards at 1 (EB-90M) of 18 sites, Al exceeded chronic standards at 5 of 18 sites, Cd and Zn both exceeded chronic standards at the same 5 of 18 sites, and Cu exceeded at 12 of 18 sites (fig. 22). Four of the six sites that did not exceed copper water-quality standards were reference sites upstream of mine-drainage contributions.

Problematic concentrations of dissolved iron are limited to EB-90M, which represented the sum of the Ely Brook watershed prior to emptying into Schoolhouse Brook. This site is more than 500 m downstream from its nearest site on Ely Brook. This site had the lowest pH and highest specific conductance of all sites included in this aquatic ecosystem assessment. The rapid natural attenuation of iron downstream of EB-90M reflected the combined influences of neutralization with attendant oxidation of ferrous iron and hydrolysis of ferric iron, and dilution.

The most problematic concentrations of dissolved aluminum were found in the lowermost pond (pond 6) and at EB-90M, which are the two sampled sites with the lowest pH. In addition, Schoolhouse Brook downstream of Ely Brook had dissolved aluminium concentrations that ranged between 97 and 143 percent of its chronic value. Dilution by the Ompompanoosuc River dropped the value well below chronic levels. The high concentrations in the Ely Brook watershed clearly reflected the control of pH on aluminum solubility, and the necessity of low pH to attack silicate minerals and release aluminum to mine drainage. The natural attenuation of aluminum concentrations to levels just above the chronic water-quality standard was due to the neutralization of drainage from Ely Brook by Schoolhouse Brook and the associated precipitation of Al hydroxides. The persistence of these concentrations down to the confluence with the Ompompanoosuc River may have reflected colloidal aluminum that reported in the dissolved fraction.

The coincidence of high concentrations of cadmium and zinc was due to their identical source in the mine waste piles—the mineral sphalerite—and the similarity of their geochemical behaviors (Seal and Hammarstrom, 2003). Cadmium and zinc exceeded water-quality criteria in the two lowermost

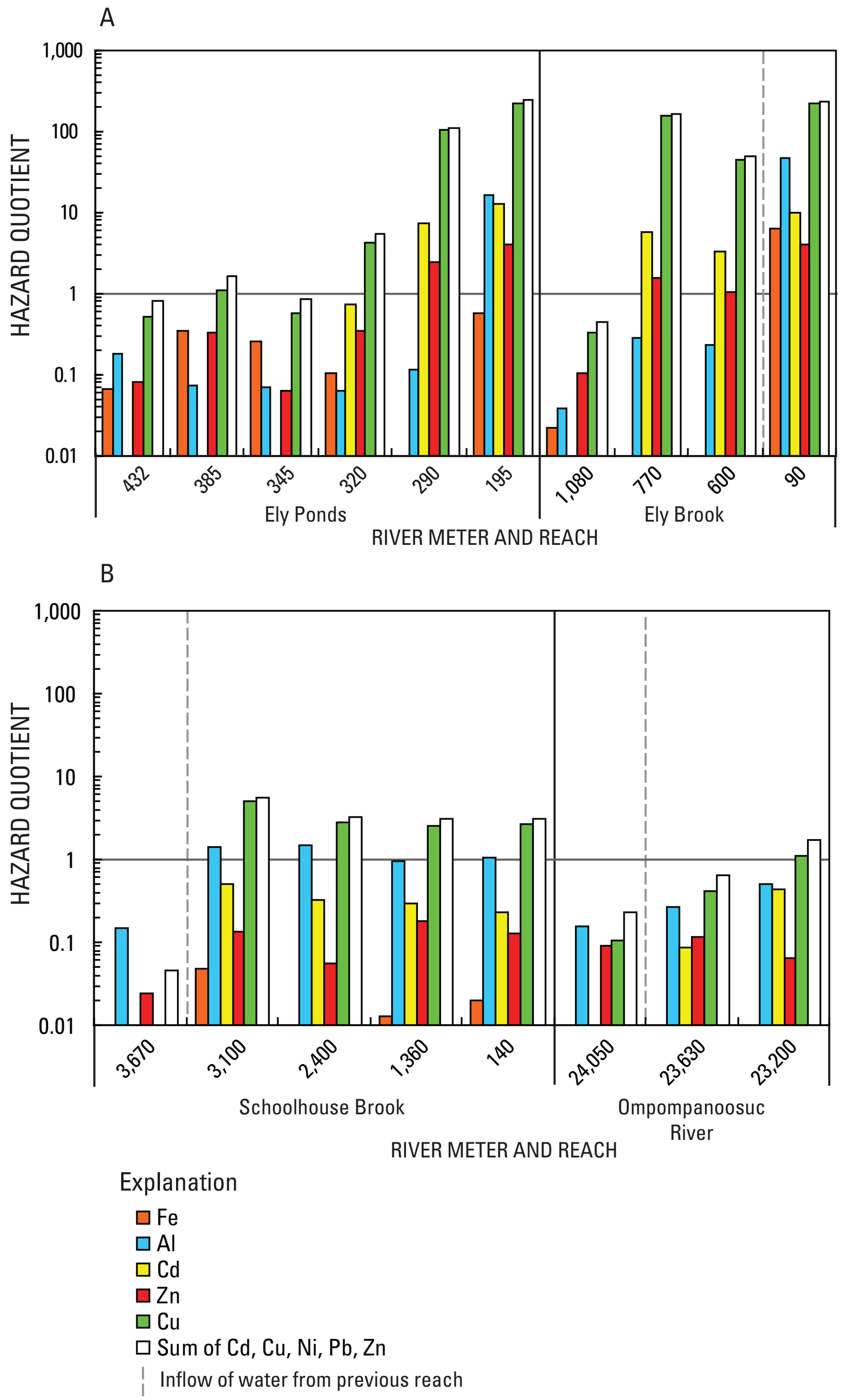


Figure 22. Downstream variations in aluminum, iron, cadmium, copper, and zinc hazard quotients in surface waters at the Ely Mine Superfund site, Vershire, VT. *A,* Ely ponds and Ely Brook; *B,* Schoolhouse Brook and the Ompompanoosuc River.

ponds, and throughout Ely Brook except for the reference site at the head waters (fig. 22). The fact that the HQ for cadmium relative to the chronic water-quality standards was far greater than that for zinc was a reflection of the low concentrations of the chronic standard for cadmium rather than its concentration in the watershed.

The concentrations of dissolved copper were most problematic and widespread of all of the contaminants in the vicinity of the site. In fact, comparison of HQs for copper relative to hardness-based chronic water-quality standards with the sum of HQs for Cd, Cu, Ni, Pb, and Zn clearly demonstrated that Cu was the dominant contaminant at all sample sites (fig. 22). Four of the six ponds exceeded chronic water-quality standards, as do all of Ely Brook and Schoolhouse Brook, except for the reference sites. Interestingly, the most downstream site on the Ompompanoosuc River (OR-23200M) marginally exceeded the chronic standards, whereas none of the sites closer to the source did.

Copper is the only element at present to have its USEPA (2006) hardness-based aquatic water-quality criteria superseded by aquatic criteria based on the Biotic Ligand Model (Paquin and others, 2002; USEPA, 2007). Throughout most of the watershed, water-quality criteria calculated using both methods were similar, but significant differences were apparent in some of the Ely ponds and in Ely Brook as reflected by a comparison of HQs based on the two methods (fig. 23). For the ponds with the distinctly disparate HQs between the two methods (pond 5 and pond 6), the water chemistry had distinctly lower DOC concentrations and alkalinity, and higher concentrations of sulfate, Cl, K, and Na, all of which were parameters used in the Biotic Ligand approach, but not the hardness-based approach. For Ely Brook, the disparate samples (EB-770M, EB-600M, EB-90M) were distinguished by their higher sulfate, Cl, Na, and K concentrations, as well as their low alkalinity. Both calcium and magnesium were higher in the lowermost Ely ponds, and in Ely Brook, but both approaches account for these differences. In the Ompompanoosuc River, the hardness-based HQs were higher than the Biotic Ligand Model quotients. This difference was likely due to the fact that the DOC concentrations in the Ompompanoosuc River were roughly twice those in Schoolhouse Brook.

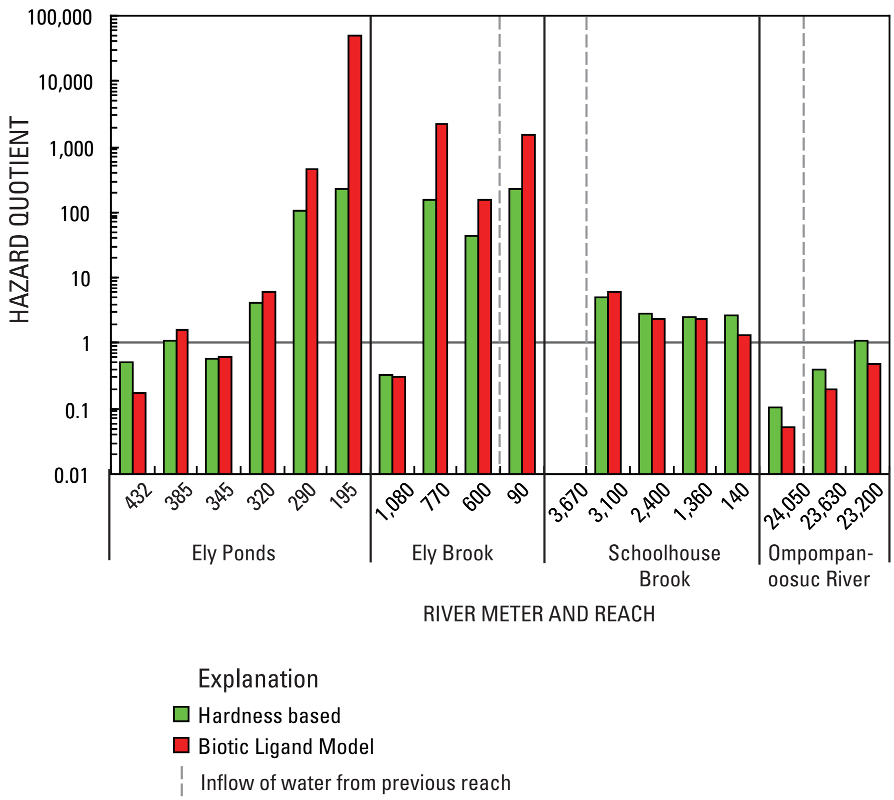


Figure 23. Downstream variations in hardness-based and Biotic Ligand Model–based hazard quotients for copper in surface waters at the Ely Mine Superfund site, Vershire, VT.

Sediment and Pore-Water Toxicity

Sediments from the 11 Ely Mine sites had similar physical and chemical characteristics (table 6 and appendix 4). All samples were dominated by sand-sized particles (67–94 percent) and had low levels of silt- and clay-sized particles (5–13 percent). All sediments had low levels of TOC and AVS, and these constituents were very consistent among locations. Sediments from Ely Brook, except the reference site EB-1080M, had high concentrations of iron (>5 percent) and manganese (>1 percent). Most pore waters had neutral to slightly alkaline pH, except for slightly acidic (pH 6.1) pore waters from EB-770M and the highly acidic (pH 3.0) pore water from EB-90M sediments. Site EB-90M pore waters also had very high concentrations of aluminum and iron, typical of waters affected by acid-mine drainage.

Sediment and pore waters from sites in Ely Brook, downstream of the mining area, had greater concentrations of metals than those from sites farther downstream from the mining area. Total copper concentrations in sediments from sites EB-770M, EB-600M, and EB-90M (table 6) exceeded PEC values, which are associated with greater risks of toxicity in sediment toxicity tests (MacDonald and others, 2000), by factors from 8 to 40. All three sediment samples from Schoolhouse Brook downstream of the confluence of Ely Brook also exceeded the copper PEC. Sediments from sites in Ely Brook also had greatest concentrations of Cr, Cd, Ni, Zn, and Pb, although none of these metals exceeded PECs except Pb concentrations in the EB-600M sediment. Total metal concentrations did not show a pattern of consistent decrease downstream from Ely Brook, although concentrations of several metals were substantially lower in sediments from OR-23200M compared to upstream sites. Metals in SEM extracts followed patterns similar to those of total metals, except that greatest concentrations of SEM Cu, Cd, Ni, and Zn occurred in sediments from EB-600M rather than EB-90M. Only about 1 percent of the total copper in EB-90M sediments was in labile forms, compared to one-third of the total copper in EB-600M sediments. Metal concentrations in pore waters followed trends more similar to total metal concentrations. Pore waters of sediments from Ely Brook, particularly those from EB-90M, also had greatest concentrations of Cd, Cu, Ni, Pb, and Zn. Concentrations of Cu and Cd in pore waters from all three Ely Brook sediment sites downstream from the reference site exceeded hardness-adjusted chronic water quality criteria (table 11; USEPA, 2006) for all three pore-water sample types—in situ, centrifuged, and 28-day equilibration samples. Zinc concentrations in pore waters locally exceeded hardness-adjusted chronic criteria in various sample types at EB-600M and EB-90M. Downstream in Schoolhouse Brook, hardness-adjusted chronic water-quality criteria for copper were exceeded at all sites for at least one pore-water sample type, but no exceedances were found for Cd or Zn in any sample. In the Ompompanoosuc River, copper exceeded the hardness-adjusted chronic water-quality criteria only for the 28-day equilibrated pore-water sample at OR-23200M.

Indices of toxicity risk based on total sediment metals, metals in the SEM fraction, and pore-water metals indicated a wide range of toxicity risks among the eleven study sites (fig. 24). An index based on the probable effects quotient (PEQ) for total sediment metals (ΣPEQ = sum of [total metal concentration/PEC]) indicated greatest toxicity risk for sediments from Ely Brook, with ΣPEQ values ranging from 10 (EB-770M) to 42 (EB-90M).

Ingersoll and others (2001) documented greater than 50 percent frequency of toxicity in tests with *H. azteca* and *C. tentans* in metals-contaminated sediments with mean PEQ values of 1.0 or greater—values equivalent to ΣPEQ of 6 or greater in this study. The ΣPEQ index indicated lower toxicity risks for sediments from downstream sites (ΣPEQ from 1.3 to 2.8) and reference sites (ΣPEQ from 0.7 to 1.7). An index based on pore-water toxic units (ΣTU = sum of [pore-water metal/chronic water-quality criterion]) followed a similar pattern. For each reach, the ΣTU value for each reference site was lower than those on the same reach and downstream of inputs of mine-influenced water and sediment. In the mineralized Ely Brook watershed, the ΣTU value at the reference site (EB-1080M) was greater than 1, whereas at the reference sites in Schoolhouse Brook (SB-360M) and the Ompompanoosuc River (OR-24050M), the values were less than 1. The pore-water toxicity units for Ely Brook steadily increase downstream, reaching a maximum of 270 at site EB-90M (fig. 25). The pore-water ΣTU values drop dramatically upon entering Schoolhouse Brook and fluctuate slightly above or below 1 throughout Schoolhouse Brook and downstream to the lowermost sampling site on the Ompompanoosuc River (OR-23200M) (fig. 25).

The ESB index proposed by USEPA (2005), which adjusts SEM concentrations to approximate binding of metals by AVS and organic carbon (ESB index = $\Sigma SEM–AVS/f_{OC}$), suggested a slightly different pattern of toxicity risks, with greatest risks for EB-770M and EB-600M sediments, lower risks for sediments from EB-90M and Schoolhouse Brook, and no risk of metal toxicity (that is, negative index values) for sediments from OR-23200M and all reference sites. ESB indices for sediment from EB-600M exceeded the USEPA (2005) benchmark for probable toxicity (3,000 µmol/gOC). Other sediments collected from the mining-affected reach of Ely and Schoolhouse Brooks fell into the range of uncertain toxicity (130–3,000 µmol/gOC).

Table 11. Summary of the concentration, hazard quotient, and hazard index for select constituents in pore waters at sampling locations in the Ely Mine study area, Vershire, VT, August and September 2006. Refer to table 1 and figure 1 for site names, station numbers, and locations.

[in situ, in situ pore water; centri., centrifuge pore water; equil., equilibrated pore water; µg/L, micrograms per liter; mg/L, milligrams per liter; <, analyte not detected at the reporting level; ins, insufficent sample; —, not determined]

Stream and location	Concentration (µg/L)															Concentration (mg/L $CaCO_3$)		
	Cadmium			Copper			Nickel			Lead			Zinc			Hardness		
	in situ	centri.	equil.	in situ	centri.	equil.	in situ	centri.	equil.	in situ	centri.	equil.	in situ	centri.	equil.	in situ	centri.	equil.
Ely Brook																		
EB-1080M	<0.02	1.66	0.11	2.4	10.2	4.3	0.6	1.4	1.7	0.06	0.91	<0.05	1.5	29.2	1.6	36	80	200
EB-770M	0.28	1.25	1.95	27.4	43.4	106	4.3	12.6	20	0.2	<0.05	<0.05	25.1	50	114	46	102	178
EB-600M	0.3	0.34	0.59	42.7	108	59.6	4	3.9	4.5	<0.05	0.08	<0.05	31.6	24.8	26	45	52	67
EB-90M	1.85	2.87	2.62	1,800	2,140	1,700	17.4	31.1	39	1.9	1.2	1.7	314	514	616	73	108	103
Schoolhouse Brook																		
SB-3670M	<0.02	0.04	0.04	<0.5	1	2.9	<0.4	2.4	4.1	0.06	0.1	0.1	1.9	3.8	4.4	111	172	278
SB-2400M	0.08	0.15	0.3	7.9	16.8	22.8	0.5	2.9	2.6	<0.05	0.1	0.05	3	6.4	4.9	130	197	252
SB-1360M	0.05	0.17	0.27	9.6	18.1	24.9	0.8	2.2	2.2	0.2	0.09	<0.05	149	6	7	94	143	257
SB-140M	0.04	0.22	0.4	5.6	8.5	21.6	0.6	2.6	2.2	0.2	0.1	0.1	8	5.3	7.4	108	178	276
Ompompanoosuc River																		
OR-24050M	<0.02	ins	0.04	0.56	ins	1.6	0.4	ins	3.8	<0.05	ins	0.09	3.8	ins	2.4	141	188	374
OR-23200M	0.06	0.19	0.09	4.5	14.2	19.1	0.8	2.8	2.2	0.3	0.09	0.2	2.9	3.4	5.7	96	187	234
	Hazard quotient															Hazard index		
Ely Brook																		
EB-1080M	—	7.9	0.3	0.6	1.4	0.3	0.0	0.0	0.0	0.1	0.5	—	0.6	0.0	0.1	1.3	9.7	0.7
EB-770M	2.0	5.0	5.3	6.0	4.8	7.2	0.2	0.2	0.2	0.2	—	—	0.8	0.9	0.2	9.2	11.0	12.9
EB-600M	2.1	2.2	3.2	9.4	20.9	9.4	0.2	0.1	0.1	—	0.1	—	0.4	0.4	3.7	12.0	23.7	16.4
EB-90M	9.3	11.1	10.4	262.2	223.9	185.2	0.4	0.6	0.7	1.1	0.4	0.7	5.7	4.9	0.0	278.7	240.8	197.0
Schoolhouse Brook																		
SB-3670M	—	0.1	0.1	—	0.1	0.1	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
SB-2400M	0.3	0.4	0.6	0.7	1.0	1.2	0.0	0.0	0.0	—	0.0	0.0	0.0	0.0	0.6	1.0	1.5	2.4
SB-1360M	0.2	0.5	0.6	1.1	1.5	1.2	0.0	0.0	0.0	0.1	0.0	—	0.1	0.0	0.0	1.5	2.1	1.9
SB-140M	0.2	0.6	0.8	0.6	0.6	1.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.9	1.3	1.9
Ompompanoosuc River																		
OR-24050M	—	—	0.1	0.0	—	0.1	0.0	—	0.0	—	—	0.0	—	0.0	0.0	0.0	0.0	0.2
OR-23200M	0.3	0.5	0.2	0.5	0.9	1.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.9	1.5	1.3

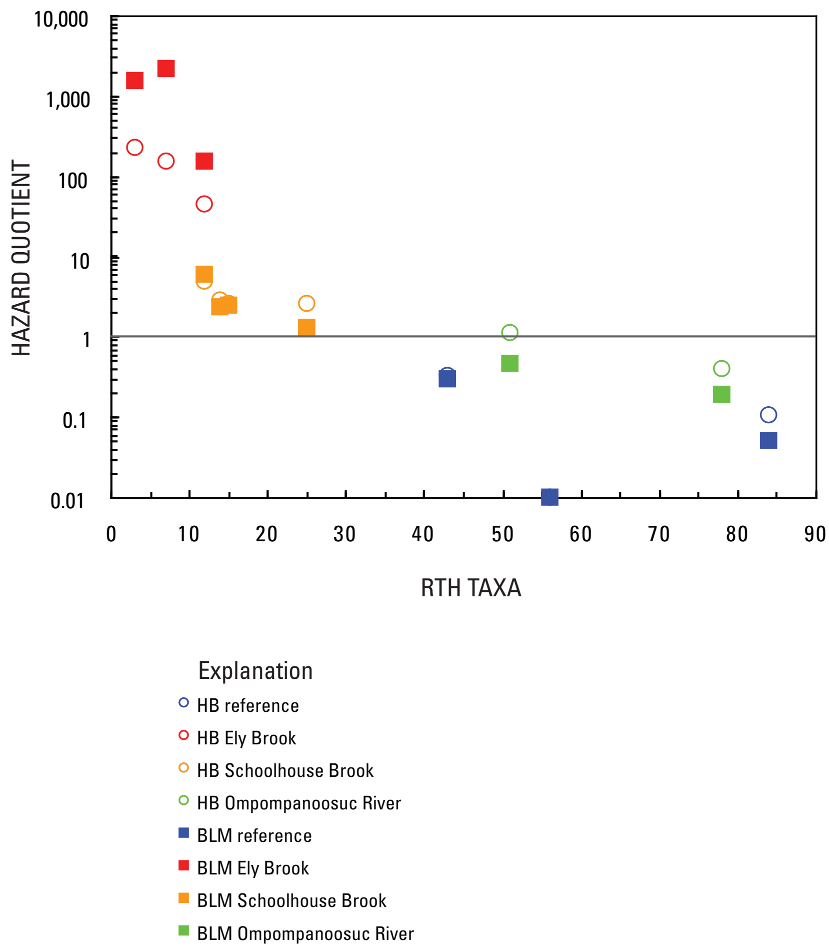


Figure 24. Chronic copper water-quality criteria for surface water based on hardness (HB) (U.S. Environmental Protection Agency, 2006) and the Biotic Ligand Model (BLM) (USEPA, 2007) with the number of riffle-targeted habitat (RTH) taxa.

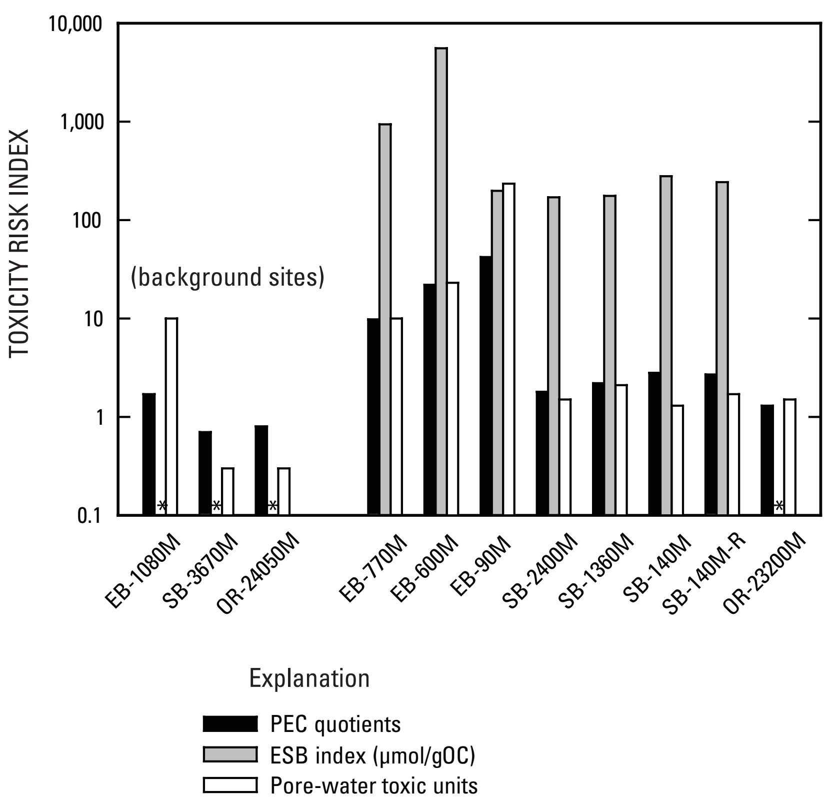


Figure 25. Three indices of metal toxicity risks for instream sediments from the Ely Mine site, August 2006. The probable effects concentration (PEC) quotients are sums of total sediment metal concentration divided by probable effect concentration (MacDonald and others, 2000). The equilibrium-partitioning sediment benchmark (ESB) index is the difference between the sum of the concentration of simultaneously extractable metals and the acid volatile sulfide concentration, both expressed as micromoles per kilogram of sediment, divided by the fraction of total organic carbon (OC) on a mass basis [ΣSEM-AVS/f_{OC}] (USEPA, 2005). Toxic units are sums of pore-water metal concentration divided by water-quality criterion (U.S. Environmental Protection Agency, 2004). Asterisks indicate values less than zero. Sample SB-140M-R is a lab replicate of SB-140M.

Bioassay Results

Survival and growth of *H. azteca* provided clear evidence for toxicity of sediments collected downstream of the mining area (table 8). Both survival and growth of amphipods differed significantly among sediments in the overall ANOVA and in the separate ANOVAs for Ely Brook and Schoolhouse Brook but not Ompompanoosuc River. Amphipod survival was high (96 percent) in the control sediment, and the arithmetic means for survival and growth were consistent among the control and the three reference sediments. Both amphipod endpoints followed similar patterns among sites, with significant toxic effects (significant reductions relative to reference sediments) occurring in six of seven sites in the reach of Ely Brook and Schoolhouse Brook, from EB-770M downstream to SB-140M. Greatest effects on both survival and growth occurred in EB-600M sediments, with survival reduced by about 80 percent and growth reduced by about 40 percent, relative to reference sites. There was no evidence of toxicity to amphipods in sediments from EB-90M or in sediments from the most downstream site, OR-23200M.

Results of the midge toxicity tests indicated significant toxic effects of sediments downstream of the Ely Mine site on midge growth but not on survival (table 8). Midge survival in the control sediment (86 percent) was above the minimum for test acceptability (70 percent; ASTM, 2007), but survival varied widely (64–90 percent) among the three reference sediments. Survival differed significantly among sediments in the overall ANOVA, but there were no significant reductions relative to reference sediments. There was a general trend for increasing midge survival with distance downstream, with differences among sites in each stream (including reference sites) being less than differences among the three streams. Growth of midge larvae also differed significantly among sediments in the overall ANOVA, and differences among treatments followed trends similar to those observed for amphipod survival and growth. Midge growth in reference sediments from all three study streams fell within a narrow range (1.00–1.21 mg AFDW), but sediments from most sites in Ely and Schoolhouse Brooks caused significantly lower growth than reference sediments in these streams. As was observed in the amphipod test, greatest reductions in midge growth occurred in sediments from EB-600M, and there were no significant effects on growth in the EB-90M and OR-23200M sediments. Of the six sediments that caused significant reductions in amphipod endpoints, only SB-1360M did not cause significant reductions in midge growth, relative to the reference sediment.

The increased survival for both species associated with sediment from site EB-90M, despite its being the most being the most toxic with respect to surface and pore water, is intriguing. The low pH of the surface and pore water would act to strip labile metals from the sediments, making whatever metal remains more refractory and less bioavailable. The SEM-AVS results for site EB-90M support this hypothesis. The copper concentration and Cu/Fe ratio of the sediments at EB-90M are among the highest in the study area, but the simultaneously extractable copper is the lowest in the study area (fig. 26). Alternatively, the pre-test flushing of the sediment with moderately hard test water (100 mg/L $CaCO_3$) with moderate alkalinity may have artificially resulted in the precipitation of hydrated ferric oxides, which may have sequestered trace metals, rendering them unavailable.

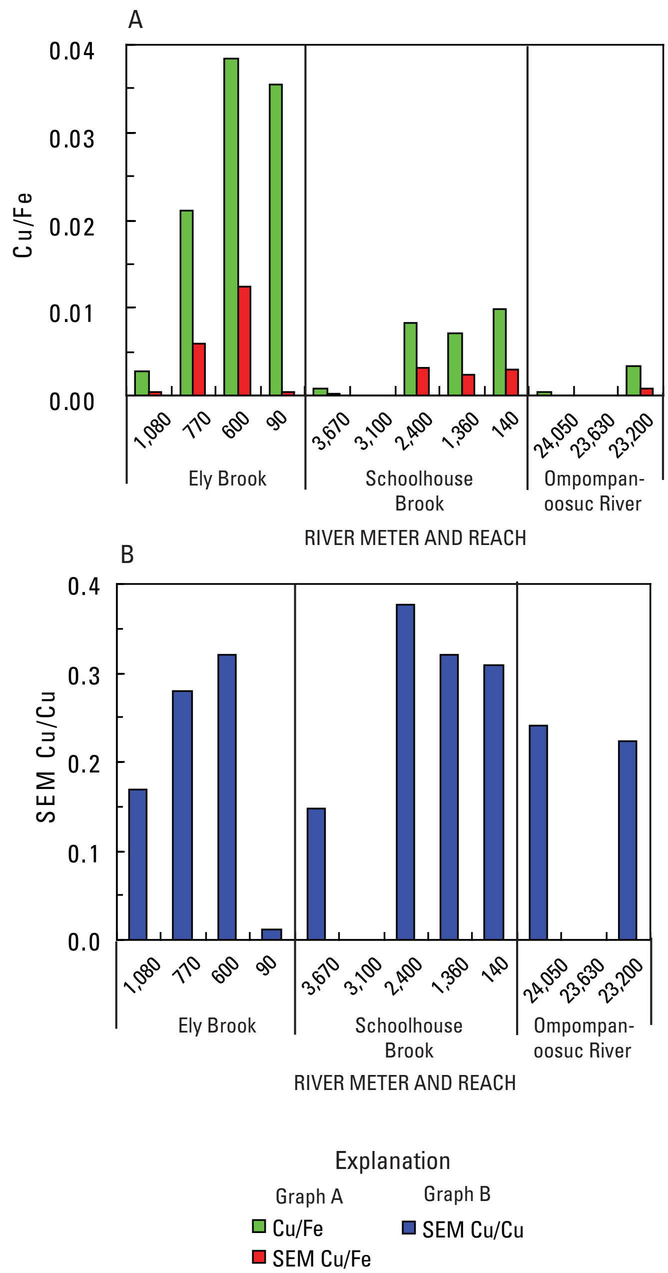


Figure 26. Copper (Cu) and iron (Fe) concentrations in stream sediments. Sites with no bars represent sites without samples. *A,* The variation within the watershed of the mass ratio of total Cu to total Fe, and the mass ratio of labile (SEM) Cu to total Fe. *B,* The variation within the watershed of the ratio labile (SEM) Cu to total Cu.

Ecological Indicators

The results of this study strongly indicated that the waterways that were investigated were impaired by acid-mine drainage from the Ely Mine site. Values of invertebrate abundance and richness were highest at reference sites, which were located above acid-rock drainage inflow for all waterways: Ely Brook, Ely ponds, Schoolhouse Brook, and Ompompanoosuc River. Fish IBI scores followed the same trend except in the Ompompanoosuc River, where the scores were as high as the reference-site IBI score. The extent of impairment to invertebrates and fish also appeared to be related to the HI values derived from the surface-water and pore-water samples.

Surface-water HI values were less than 1.0 at all reference sites for all streams, and an increase in the HI values corresponded to an increase in impairment (lower abundance and richness in RTH samples). The Ompompanoosuc River site downstream from the confluence of Schoolhouse Brook (OR-23630) was one of only two non-reference sites for a stream that had a surface-water HI value below 1.0; RTH taxa richness was only slightly lower than the reference (OR-24050), and the site was not categorized as impaired by VTDEC. The QMH invertebrate data from the ponds also indicated that impairment was related to the surface-water HIs. Although the HI at pond 2 was 1.6, impairment was relatively minor compared to pond 4, which had substantially lower invertebrate abundance and richness values, and the HI was 5.6.

Pore-water HIs were also less than 1.0 at all reference sites except for the in situ and centrifuged samples at EB-1080M. Impairment to the RTH invertebrate assemblages in Ely Brook strongly corresponded to a very large increase in the HIs downstream of the reference (HI from 1.3 to 279). However, severe impairment to the DTH invertebrate assemblages also occurred in Schoolhouse Brook downstream from the confluence with Ely Brook, although the pore-water HI was only 1 at the first site downstream from the confluence of Ely Brook that was sampled for DTH invertebrate assemblages (SB-2400M), although this was not the site immediately below the confluence (SB-3100M). This stream was characterized as high gradient, and there were only a few depositional areas from which to collect samples. These areas were typically small and the depositional material most likely transient in its placement. Therefore, the DTH invertebrate assemblages are probably affected by surface-water flows and contamination as well as pore-water contamination. Such interactions are also likely throughout the water bodies affected by acid-rock drainage, where a certain amount of residual toxicity in the sediments affects invertebrate assemblages, but toxicity would increase during storm events as contaminant concentrations increase in the overlying surface waters. Furthermore, this interaction would be most pronounced nearer the source of contamination because contaminants in surface water would be diluted farther downstream as additional water is added from the increasing area of the drainage basin.

To determine the extent of impairment to streams affected by Ely Mine, the VTDEC has made biological assessments to Ely Brook and Schoolhouse Brook for two decades and to the Ompompanoosuc River since 2001 (VTDEC, 2008). These assessments have been based on the fish and macroinvertebrate assemblages (for example, RTH) similar to the surveys conducted for this report, and the results are directly comparable (table 9). Ely Brook was first assessed as “poor” in 1987, based on the invertebrate assemblage surveyed that year at a site that corresponds to EB-90M from this study. Using the RTH invertebrate data from this study, VTDEC assessed the four Ely Brook sites below the acid-rock drainage inflow as “poor” and the site above the acid-rock drainage inflow as “very good to good.” The VTDEC also made determinations of whether stream segments were supporting of aquatic life for Class B waters in Vermont, and only the segment above acid-rock drainage inflow was supporting for Ely Brook.

Surveys of fish, invertebrates, or both have occurred at sites along Schoolhouse Brook in 1987, 1988, 1997, 2000, 2001, and for this study in 2006 (table 12). Assessments based on fish assemblages have ranged from “good” to “excellent” at sites above acid-rock drainage inflow (that is, Ely Brook confluence), and “poor” for sites below acid-rock drainage inflow except for a “fair” assessment for the most downstream site for 2006, based on the fish survey from this study. Invertebrate assemblages in Schoolhouse Brook were assessed as “good” to “excellent” at two sites above acid-rock drainage inflow, and consistently “poor” at sites below acid-rock drainage inflow. The aquatic-life use determination by VTDEC was that the segment of Schoolhouse Brook above acid-rock drainage inflow was supporting for Class B waters but that the entire section below acid-rock drainage was non-supporting.

Surveys of fish in the Ompompanoosuc River were conducted in 2001, 2002, 2006, and 2007, and invertebrate assemblages were surveyed in 2005 and 2006 (table 12). Data from the 2006 and 2007 surveys were collected for this study. Assessments based on fish assemblages were either “good” or “very good” upstream of acid-rock drainage inflow (that is, Schoolhouse Brook confluence) but were either “poor” or “good” below the acid-rock drainage inflow. Only in this segment of the Ompompanoosuc River (below the confluence with Schoolhouse Brook) was there any variation in the assessment over time, which may have been caused by acid-rock drainage or by other factors. From the data collected for this study, the difference in the 2006 and 2007 “poor” and “good” assessments, respectively, was based on fewer fish collected and not a difference in assemblage structure. Lower abundance could be a result of contamination but also a result of less habitat structure or low capturing efficiency during the sampling effort. In 2002, the VTDEC made an assessment of “poor” based on a fish survey at a site about 3 km below the Schoolhouse Brook confluence. However, the VTDEC had conducted a fish survey at a site about 6 km farther downstream; this site was assessed as “good” and had an IBI score (35) that exceeded the Ompompanoosuc reference site score (33).

Table 12. Summary of the aquatic-life use (ALU) assessments for streams associated with the Ely Mine site.

[The assessments were derived by the State of Vermont (VTDEC) with data from this study (dates in red font) and from previous studies (VTDEC, 2008). Note that VTDEC uses river mile to designate site locations. The designation "*ARD inflow*" indicates the relative location along the stream where acid-rock drainage affects water quality. For the fish index of biotic integrity (IBI) scores, MW or CW next to the value indicates a mixed water or cold water index, respectively, was used for the assessment. The ALU determination (last column) indicates whether or not the stream is supporting of Class B waters in Vermont, based on the assessments of fish and invertebrate assemblages]

VTDEC site (river mile)	USGS site designation	Fish survey date	Fish assessment	Fish IBI score	Invertebrate survey date	Invertebrate assessment	Invertebrate density[a]	Invertebrate richness[a]	ALU determination
Ely Brook (Schoolhouse Brook Tributary 3)—small high-gradient stream (SHG)									
0.9	EB-1080M				**09-06-2006**	Very good/Good	1,744	40	Supporting
→*ARD inflow* ~~~~~~~~~~~~~~~~~~~~									
0.7	EB-770M				**09-06-2006**	Poor	8	7	Non-supporting
0.4	EB-600M				**09-06-2006**	Poor	37	11	Non-supporting
0.1	EB-90M				**09-06-2006**	Poor	38	3	Non-supporting
					09-30-1987	Poor	1	1	
Schoolhouse Brook—small high-gradient stream (SHG)									
2.4	SB-3670M	**09-13-2006**	Excellent	42 CW	**09-06-1006**	Good	3,440	48	Supporting
		09-19-2000	Excellent	45 CW	10-25-2001	Excellent	1,175	44	Supporting
2.3		09-10-1997	Very Good	39 CW	09-10-1997	Excellent	574	45	
		07-08-1988	Good	33 CW	09-30-1987	Excellent	224	42	
→ *ARD inflow* ~~~~~~~~~~~~~~~~~~~~									
2.2	SB-3100M	**09-13-2006**	Poor	9 CW	**09-06-2006**	Poor	25	12	Non-supporting
		09-19-2000	Poor	9 CW	10-25-2001	Poor	14	8	
		09-10-1997	Poor	9 CW	09-10-1997	Poor	29	13	
		07-07-1988	Poor	9 CW	09-30-1987	Poor	8	6	
1.7	SB-2400M	**09-13-2006**	Poor	9 CW	**09-06-2006**	Poor	96	12	Non-supporting
1.0	SB-1360M	**09-13-2006**	Poor	18 CW	**09-06-2006**	Poor	73	13	Non-supporting
0.4		10-25-2001	Poor	9 MW	10-25-2001	Poor	82	18	Non-supporting
					09-30-1987	Poor	3	3	Non-supporting
0.2	SB-140M	**09-13-2006**	Fair	29 MW	**09-06-2006**	Poor	274	17	Non-supporting
Ompompanoosuc River—medium-gradient stream (MHG)									
16.1	OR-24050M	10-25-2001	Very Good	37 MW					Supporting
		09-12-2006	Good	33 MW	**09/06/2006**	Excellent/Very good	2,862	69	
→ *ARD inflow* ~~~~~~~~~~~~~~~~~~~~									
15.9	OR-23630M	**09-12-2006**	Good	33 MW	**09/06/2006**	Good	3,114	63	Supporting
15.6	OR-23200M	**09-12-2006**	Poor	9 MW	**09/06/2006**	Good	1,920	48	Supporting
		09-11-2007	Good	33 MW					
13.8		07-11-2002	Poor	9 MW					
10.1		09-11-2001	Good	35 MW					Supporting
7.3					09-26-2005	Very good	1,325	46	Supporting

[a] Invertebrate density and richness values that are based on data from this study (dates shown in red font) are shown here as lower than abundance and richness values in table 9 in some cases. This difference occurs because VTDEC does not include all taxa in deriving metrics used for biological assessments.

The invertebrate assemblages at the Ompompanoosuc River reference site were surveyed only once (data from this study) but were assessed as "excellent" to "very good." Downstream from the acid-rock drainage inflow, the assessments were slightly downgraded to "good," based on the 2006 data for this study, but "very good" for a 2005 invertebrate survey at a site about 13.5 km downstream from Schoolhouse Brook. Comprehensively, the results from the fish and invertebrate surveys on the Ompompanoosuc River indicate that there may be some degree of impairment to the river from acid-rock drainage.

The indication of a slight increase in the impairment at site OR-23200M, even compared to site OR-23630 (immediately below Schoolhouse Brook), was supported by the HI values for surface water; of the three Ompompanoosuc River sites in this study, the HI exceeded 1.0 only at site OR-23200M. However, if acid-rock drainage is responsible for any degree of impairment to biological assemblages in the Ompompanoosuc River, they were relatively minor; the determination by VTDEC was that the segments upstream and downstream from the acid-rock drainage inflow were all supporting of Class B waters (table 12).

Comparison of Aquatic Ecosystem Health Indicators

The geochemical data for surface waters and sediments, along with toxicity testing data, and ecological data all provide a reasonably consistent assessment of downstream aquatic ecosystem impairment related to the Ely Mine and are summarized in table 13 for the stream habitat and table 14 for the pond habitat. The results provide strong evidence that acidity and metals from the Ely Mine site have contaminated surface waters and sediments in Ely and Schoolhouse Brooks, leading to toxic effects on fish and benthic invertebrates. Analyses of metal concentration in surface waters, sediment, and pore water indicated that toxicity risks downstream of the Ely Mine site were driven primarily by high copper concentrations in all media, although other metals (Al, Cd, Cr, Fe, Ni, Pb, and Zn) may have contributed locally to toxicity.

In terms of surface water, there are essentially no differences in the reaches exceeding acute and chronic water-quality criteria with the exception of site OR-23200M, which exceeds the chronic but not acute criterion. Surface-water toxicity tests showed identical impairment throughout Ely Brook and Schoolhouse Brook. Riffle-habitat invertebrates downstream of reference sites in Ely Brook and Schoolhouse Brook showed significant decreases in both the number of taxa and the number of individuals. Riffle-habitat invertebrates in the Ompompanoosuc River showed no significant differences above or below the confluence with Schoolhouse Brook. For the fish community, similar results were found. The IBI showed significant impairment in Schoolhouse Brook downstream of Ely Brook, but no variation was observed in the Ompompanoosuc River.

Locally significant differences in the level of predicted copper toxicity are found when comparing water-quality standards calculated on the basis of the hardness-based criterion for copper relative to those calculated using the Biotic Ligand Model (fig. 24). The hardness-based criteria suggest significant, but lower, toxicity in the Ely Brook watershed, similar toxicity in Schoolhouse Brook, and slightly higher toxicity in the Ompompanoosuc River compared to the Biotic Ligand Model criteria. Nevertheless, both approaches identify similar reaches of impairment, which are consistent with ecological indicators such as the number of riffle-habitat invertebrate taxa present (fig. 24).

Indicators of surface-water quality in the ponds along tributary 2 to Ely Brook were consistent. Ponds with impaired water quality exceeded both the acute and chronic criteria (ponds 4, 5, and 6), whereas pond 2 only minimally exceeded the chronic criterion (HQ = 1.1). Qualitative multi-habitat measures of the number of taxa and the number of individuals showed systematic decreases relative to the reference site (pond 1).

Results of the whole-sediment toxicity tests for Ely Brook, Schoolhouse Brook, and the Ompompanoosuc River were generally consistent with other measures of biological impacts of sediment and pore water of streams draining the Ely Mine site. Copper concentrations in sediments indicate impairment relative to probable effects concentrations at all sites in Ely Brook and Schoolhouse Brook, except the reference sites. In contrast, partitioning sediment benchmarks predict no toxicity at the reference sites and in the Ompompanoosuc River and uncertain toxicity at all others sites in Ely Brook and Schoolhouse Brook, except site EB-600M for which toxicity is predicted.

Acute toxicity tests conducted by the USEPA with pore waters sampled in situ at the time of whole sediment sampling indicated acute lethal effects on amphipods in pore waters from Ely Brook (including 100 percent lethality in EB-90M pore waters), where our test indicated no chronic toxicity, but the acute tests indicated no toxic effects of pore water from Schoolhouse Brook, where our chronic, whole-sediment tests found effects on both amphipods and midges (fig. 25). These differences may be due to two separate factors. The differences may reflect the greater sensitivity of the chronic tests, and they may also be due to an apparent loss of toxicity due to the neutralization of acidic EB-90M pore waters as an artifact of the chronic test protocol. Results of both sets of toxicity tests are consistent with surveys of resident benthic invertebrates at these study sites, which demonstrated severe effects on communities at sites downgradient of mining in Ely Brook and lesser effects in the Schoolhouse Brook study reach.

Significant toxic effects on amphipods (reduced survival and growth) and midges (reduced survival) occurred in sediments from Ely Brook. These toxic effects persisted throughout the reach of Schoolhouse Brook downstream of the confluence of Ely Brook, but there was no evidence of sediment toxicity in the Ompompanoosuc River downstream of the confluence of Schoolhouse Brook. Midge survival did not indicate significant toxic effects of these sediments, consistent with previous studies with metal-contaminated sediments that have reported that amphipod survival and midge growth are more sensitive endpoints than midge survival (Phipps and others, 1995; Besser and others, 2008). Within the affected reach, all sediment samples caused significant reductions of all three sensitive endpoints (relative to reference sites) except sediments from EB-90M, which were not toxic to either amphipods or midges, and sediments from SB-1360M, which were toxic to amphipods but not to midges (table 8).

The absence of toxic effects of the EB-90M sediment is remarkable, given the high total copper concentrations in this sediment and the high concentration of copper in the pore water. The lack of toxicity in the laboratory test with EB-90M sediments is probably related to the very acidic pH (2.9–3.2) of surface and pore waters collected from this site. The small fraction of total copper recovered in the SEM fraction (1.1 percent of total copper) suggests that almost all labile copper had been leached from the EB-90M sediment and that the high copper concentrations in EB-90M pore water originated from contaminated surface water or groundwater moving downgradient into the EB-90M sediments. Labile copper in the stream sediments is likely sorbed onto hydrated ferric hydroxides, which is strongly dependent upon pH. Below a

Table 13. Summary of geochemical and biological indicators of stream health in the Ely Mine study area, Vershire, VT, June to September 2006.

[AWQC, ambient water-quality criteria; HQ, hazard quotient; BLM, Biotic Ligand Model; RTH, riffle-targeted habitat; DHT, depositional-targeted habitat; IBI, fish assemblage index of biotic integrity; PEC, probable effects concentration; SEM, simultaneously extractable metals; AVS, acid volatile sulfide; f_{OC}, concentration of organic carbon; NA, not applicable; —, not determined; <, analyte not detected at reporting level; Pink cells indicate uniformly impaired conditions, green cells indicate unimpaired conditions, yellow cells indicate uncertain level of impairment, white cells indicate that no criteria were available for comparison or that the QA/QC for the test failed]

Site ID for various studies	Ely Brook				Schoolhouse Brook								Ompompanoosuc River		
USGS water ID (August 2006)	EB-1080M	EB-770M	EB-600M	EB-90M	SB-3670M		SB-3125M		SB-2400M	SB-1360M	SB-140M		OR-24050M	OR-23630M	OR-23200M
USEPA surface-water toxicity test ID (June 2006)	—	—	—	EMTT-3	EMTT-4	EMTT-5	EMTT-6	EMTT-7	—	—	—	EMMT-8	—	—	—
USGS sediment toxicity test ID (August 2006)	EB (ref)	EB2	EB3	EB4	SB1(ref)	—	—	—	SB3	SB4	SB5a	—	OR1(ref)	—	OR3
USEPA pore-water toxicity test ID (August 2006)	—	EB2	EB3	EB4	SB1(ref)	—	—	—	SB3	SB4	SB5a	—	—	—	OMP3
Surface-water quality indicators															
Surface-water chemistry HQ for Cu, compared to chronic hardness-based AWQC	0.3	153	45	222	<0.04	—	5	—	5	3	3	—	0.1	0.4	1.1
Surface-water chemistry HQ for Cu, compared to chronic BLM AWQC	0.3	2,231	153	1,508	<0.04	—	6	—	6	2	2	—	0.1	0.2	0.5
USEPA surface-water toxicity test, 7-day survival, fathead minnow (in percent)	—	—	—	0	90	3	18	15	—	—	—	48	—	—	—
USEPA surface-water toxicity test, 7-day growth, fathead minnow, average dry biomass (in milligrams)	—	—	—	0.00	0.39	0.00	0.03	0.02	—	—	—	0.10	—	—	—
RTH taxa	43	7	12	3	56	—	12	—	14	15	25	—	84	78	51
IBI	—	—	—	—	42	—	9	—	9	18	29	—	33	33	9 (habitat?)
Summary assessment based on surface-water quality indicators	good	impacted	impacted	impacted	good	impacted	impacted	impacted	impacted	impacted	impacted	impacted	good	uncertain	uncertain
Sediment-quality indicators															
Bulk sediment chemistry HQ for Cu, compared to PEC	0.5	8	18	40	0.1	—	—	—	1	1	2	—	0.03	—	0.5
(SEM - AVS)/f_{OC}	–62	963	6,050	213	–161	—	—	—	317	281	319	—	–139	—	–95
Benthic DTH taxa	34	7	4	4	30	—	—	—	14	6	21	—	21	—	17
Sediment toxicity test, 28-day survival, *Hyaleala azteca* (in percent)	94	69	6	91	94	—	—	—	53	64	53, 69[a]	—	94	—	91
Sediment toxicity test, 28-day growth, *Hyalella azteca* (in millimeters)	3.24	2.45	1.96	3.39	3.31	—	—	—	2.43	2.53	2.55, 2.48	—	3.21	—	3.17
Sediment toxicity test, 10-day survival, *Chironomus dilutus* (in percent)	64	61	65	73	76	—	—	—	80	63	68, 84	—	90	—	84
Sediment toxicity test, 10-day growth, *Chironomus dilutus*, ash-free dry weight (in milligrams)	1.21	0.61	0.28	1.73	1.00	—	—	—	0.78	1.28	0.81, 0.59	—	1.06	—	0.96
Copper SEM (in micromoles per gram)	0.2	5.4	13.8	1.1	<0.024	—	—	—	0.99	—	1.2	—	<0.017	—	0.27
In situ pore-water toxicity test, 96-hour survival, *Hyalella azteca* (in percent)	—	40	10	0	85	—	—	—	100	85	85	—	—	—	90
In situ pore-water toxicity test, 96-hour survival, *Chironomus tentans* (in percent)	—	100	100	50	100	—	—	—	90	100	90	—	—	—	100
In situ pore-water chemistry HQ for Cu, compared to chronic hardness-based AWQC	0.6	6	9	262	<0.04	—	—	—	0.7	1.1	1.6	—	0	—	0.5
Centrifuged pore-water chemistry HQ for Cu, compared to chronic hardness-based AWQC	1.4	5	21	224	0.1	—	—	—	1.0	1.5	0.6	—	—	—	0.9
Equilibrated pore-water chemistry HQ for Cu, compared to chronic hardness-based AWQC	0.3	7	9	185	0.1	—	—	—	1.2	1.2	1.0	—	0.1	—	1.0
Summary assessment based on sediment-quality indicators	good	impacted	impacted	impacted	good	—	—	—	uncertain	uncertain	uncertain	—	good	—	uncertain

[a] Sediment toxicity testing conducted in duplicate for this sample.

Table 14. Summary of geochemical and biological indicators of pond health in the Ely Mine study area, Vershire, VT, June to September 2006.

[AWQC, ambient water-quality criteria; HQ, hazard quotient; BLM, Biotic Ligand Model; QMH, qualitative multi-habitat invertebrates index; PEC, probable effects concentration; —, not determined; Pink cells indicate uniformly impaired conditions, green cells indicate unimpaired conditions, yellow cells indicate uncertain level of impairment, white cells indicate that no criteria were available for comparison or that the QA/QC for the test failed]

Site ID for various studies						
USGS water ID	**Pond 1**	**Pond 2**	**Pond 3**	**Pond 4**	**Pond 5**	**Pond 6**
USEPA surface-water toxicity test ID	NA	NA	NA	EMTT-1 (ref)	EMTT-2	NA
Surface-water quality indicators						
Surface-water chemistry HQ for Cu, compared to chronic hardness-based AWQC	0.5	1.1	0.6	4.2	103	226.9
Surface-water chemistry HQ for Cu, compared to chronic BLM AWQC	0.2	1.6	0.6	5.9	457	49,110
USEPA surface-water toxicity test, 7-day survival, fathead minnow (in percent)	—	—	—	20	0	—
USEPA surface-water toxicity test, 7-day growth, fathead minnow, average dry biomass (in milligrams)	—	—	—	0.03	0.00	—
QMH taxa	59	46	47	26	14	2
In situ wood frog egg survival until hatching (in percent)	88	—	—	94	81	—
In situ wood frog tadpole survival at hatching (in percent)	88	—	—	94	0.3	—
In situ wood frog tadpole survival 1 week after hatching (in percent)	86	—	—	38	0.0	—
Summary assessment based on surface-water exposure	good	uncertain	uncertain	impacted	impacted	impacted
Sediment-quality indicators						
Bulk sediment chemistry HQ for Cu, compared to PEC	0.6	0.6	0.6	2.6	24	12

pH of 4.0 to 4.5, essentially all of the labile copper should be in solution, whereas above that range, copper sorbs strongly to ferric hydroxides (Seal and Hammarstrom, 2003). This effect is illustrated in figure 26. Figure 26*A* shows the mass ratio of total Cu to total Fe in the sediment, and figure 26*B* shows the mass ratio of SEM Cu to total Fe in the sediment. From EB-1080M to EB-600M, the pH varied between 6.3 and 7.2, and the amount of labile Cu increased with the total amount of Cu. However, between sites EB-600M and EB-90M, the pH of Ely Brook dropped to 3.0. Although the ratio of total Cu to total Fe is high, the ratio of labile (SEM) Cu to total Fe is low, which is probably due to the mobility of labile Cu at low pH (< 4). The same trend is also reflected in the variation of labile (SEM) Cu to total Cu within the watershed (fig. 26*B*). In Ely Brook, the proportion of labile copper drops abruptly with pH, but once pH increases in Schoolhouse Brook, the proportion of labile copper once again goes up, even though the amount of total copper is lower. Because of the pH dependence of the lability of copper, somewhere between sites EB-600M and EB-90M, the bioavailability of copper in the sediments dropped dramatically with decreasing pH; the resulting limited bioavailbility persisted down to the confluence with Schoolhouse Brook. The acidic conditions have leached the labile copper and left a more refractory solid-phase copper species. Due to the pH dependence of copper solubility and sorption (Dzomback and Morel, 1990; Nordstrom and Alpers, 1999), a hypothetical increase in pH due to remediation would only serve to sequester more strongly the copper and other trace metals in the sediments.

It is also possible that the sample of acidic, high-copper EB-90M pore water collected before the start of the sediment test was not representative of conditions during the toxicity tests. During the tests, the pH of EB-90M pore waters was apparently neutralized by regular replacement of the overlying water (pH 8.2, alkalinity 100 mg/L as $CaCO_3$). Water-quality analyses of overlying water indicated slight depression of pH and alkalinity on day 0 of the test with EB-90M sediment but showed no difference from other sediments on subsequent dates. Once the high copper concentration in the original pore water was lost by dilution, precipitation, or sorption at neutral pH, the pool of bioavailable copper in this sediment was apparently too low to sustain toxic levels of copper in pore water. In contrast, the EB-600M sediment, which had lower total copper concentrations and lower pore-water copper concentrations before the toxicity test, had concentrations of SEM copper that were more than tenfold greater than those in the EB-90M sediment. The EB-600M sediment caused severe toxic effects on both midges and amphipods.

Sediment toxicity testing and SEM-AVS determinations were not done in the ponds along Ely Brook tributary 2. Nevertheless, copper concentrations relative to probable effects concentrations are consistent with surface-water quality. Ponds 4, 5 and 6 are impaired.

In general, the equilibrium-partitioning sediment benchmarks provide a more accurate assessment of sediment toxicity at the site than the PECs do. For example, both *Hyalella azteca* survival in the toxicity tests and the depositional habitat taxa correlate strongly with ESB (fig. 27*A*,*C*). The copper PEC values do appear to accurately predict effects on the infauna community in the watershed (fig. 27*D*). In the sediment toxicity tests, the copper PEC values also predict *H. azteca* survival at HQs below 1, but toxic effects are not predicted well at values above 1 (fig. 27*B*).

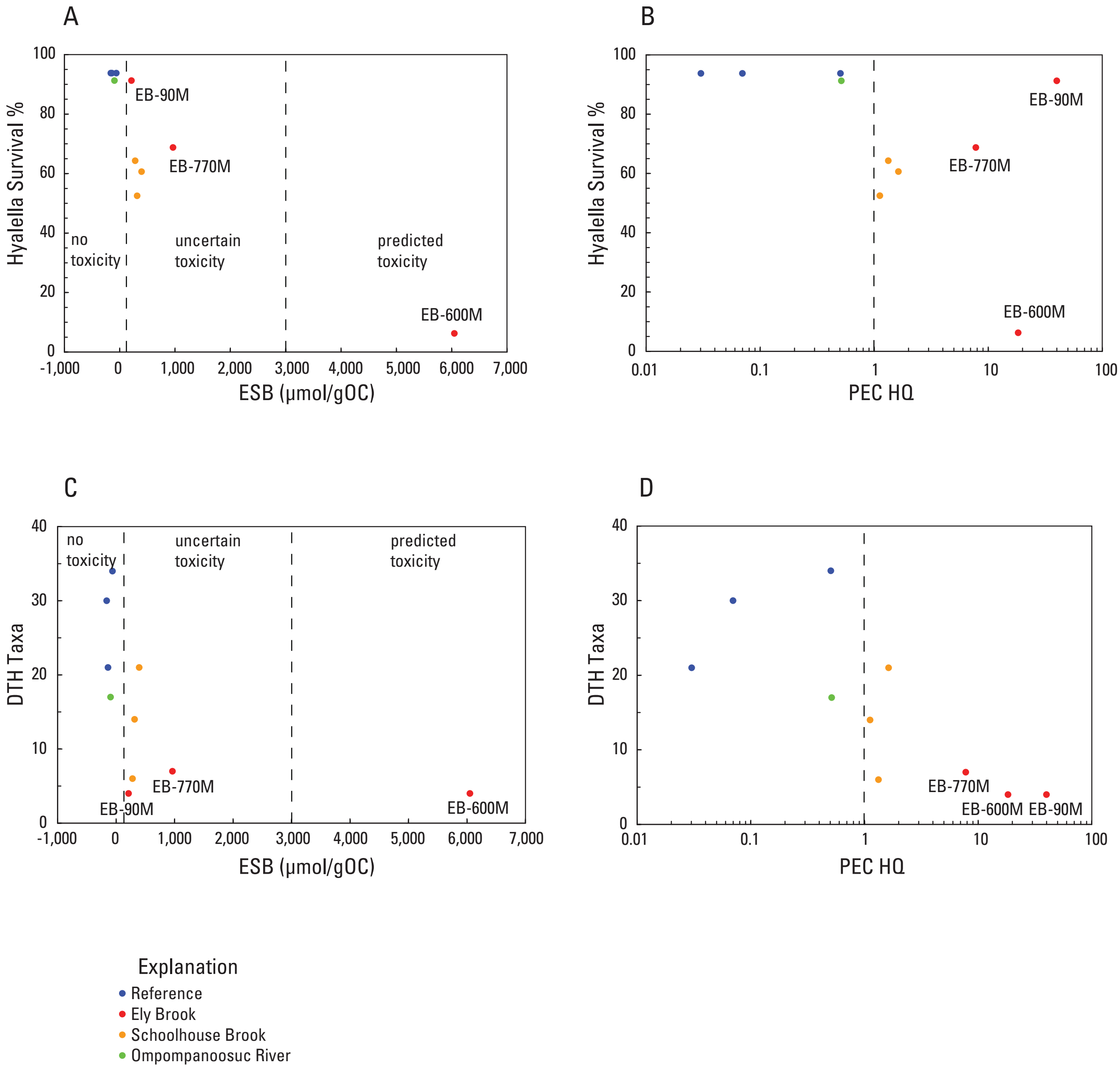


Figure 27. Comparison of sediment-quality criteria with various measures of sediment toxicity. *A,* The variation of *Hyalella azteca* survival in toxicity tests with the equilibrium-partitioning sediment benchmark (ESB). The boundaries between ESB ranges for no toxicity, uncertain toxicity, and predicted toxicity are from USEPA (2005). *B,* The variation of *Hyalella azteca* survival in toxicity tests with hazard quotients (HQ) based on the copper probable effects concentration (PEC). *C,* The variation of depositional-targeted habitiat (DTH) taxa richness with the equilibrium-partitioning sediment benchmark (ESB). The boundaries between ESB ranges for no toxicity, uncertain toxicity, and predicted toxicity are from USEPA (2005). *D,* The variation of depositional-targeted habitiat (DTH) taxa richness hazard quotients based on the copper probable effects concentration (PEC).

Conclusions

In summary, the aquatic ecosystem at the site was assessed using a variety of approaches that investigated surface-water quality, sediment quality, and various ecological indicators of stream health. The degradation of surface-water quality is dominated by Cu with localized degradation caused by Fe, Al, Cd, and Zn. Chronic water-quality criteria for copper are exceeded by four of the six ponds on the Ely Brook tributary, all of Ely Brook and Schoolhouse Brook except for the reference sites, and only the most downstream site on the Ompompanoosuc River. Comparison of hardness-based and Biotic Ligand Model-based water-quality criteria for copper yields similar results with respect to extent of impairment. However, the Biotic Ligand Model criteria are more stringent than the hardness-based criteria and suggest a greater degree of impairment, particularly in the Ely Brook watershed, where dissolved organic carbon concentrations and pH values are lower. Surface-water toxicity testing correlates strongly with the extent of impact. Likewise, riffle-habitat benthic invertebrate richness and abundance data support these results through the stream environment. Similarly, the index of biotic integrity for the fish community in Schoolhouse Brook and the Ompompanoosuc River document degraded habitats throughout Schoolhouse Brook from Ely Brook down to the Ompompanoosuc River.

The sediment environment shows similar extents of impairment dominated by copper, although localized degradation due to Cr, Ni, Pb, and Zn were documented on the basis of probable effects concentrations. In contrast, equilibrium-partitioning sediment benchmarks indicate no toxic effects would be expected in sediments at the reference sites, and uncertain toxic effects expected throughout Ely Brook and Schoolhouse Brook, except for site EB-600M. The results for site EB-600M indicate predicted toxic effects. Acute toxicity testing of in situ pore waters using *Hyalella azteca* indicates severe impacts in Ely Brook reaching 100 percent lethality at EB-90M. Acute toxicity testing of in situ pore waters using *Chironomus dilutus* shows similar, but not as severe, toxicity. Neither set of in situ pore-water toxicity tests showed significant impairment in Schoolhouse Brook or the Ompompanoosuc River. Chronic sediment toxicity testing using *Hyalella azteca* indicated significant toxicity in Ely Brook, except at EB-90M, and in Schoolhouse Brook. The low toxicity of EB-90M may be a reflection of the low lability of copper in that sediment, as indicated by a low proportion of extractable copper (1.1 percent). Toxicity testing was not done with the pond pore waters or sediments. Depositional habitat invertebrate richness and abundance data support these conclusions, as do the index of biotic integrity data from the fish community.

In general, degraded surface-water quality, particularly from copper, appears to be the dominant cause of toxicity at the site. Sediment quality is less uniformly affected, particularly downstream of Ely Brook; however, copper is also the dominant contaminant of concern in this medium.

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Test type	Whole-sediment toxicity tests
Temperature	23 °C
Lighting	16 hours light: 8 hours dark; wide-spectrum fluorescent, about 200 lux
Test sediments	Ely Mine sediments (11 samples, including reference sites) and laboratory control (soil from Florissant, MO)
Exposure chambers	300-ml high-form beaker (with 100 mL sediment)
Test water	Diluted Columbia Environmental Research Center (CERC) well water (target hardness 100 mg/L)
Water renewal	2 volume-additions per day
Test organisms	Amphipod, *Hyalella azteca;* Midge, *Chironomus dilutus*
Age of organisms	Amphipods, about 8 days old; midge larvae, about 10 days old (second instar)
Number of organisms	10 per replicate
Replication	8 replicates of each species per sediment
Feeding	Amphipods: 6 mg yeast-cerophyll-trout chow (YCT) per day (USEPA, 2000) Midges, 6 mg flake fish food suspension per day
Water quality	Dissolved oxygen, conductivity, pH, alkalinity, hardness, ammonia (biweekly in overlying water)
Sediment analyses	Sediment: particle-size distribution, total organic carbon, total metals, simultaneously extractable metals, acid-volatile sulfides Pore water: dissolved metals, dissolved organic carbon
Test duration	28 days (amphipods); 10 days (midges)
Test endpoints	Amphipods: survival and growth (length) Midges: survival and growth (ash-free dry weight)
Test acceptability	Control survival: ≥80 percent for amphipods, ≥70 percent for midges

Appendix 2. Quality-assurance, quality-control water samples for the Ely Mine study, Vershire, VT.

[µg/L, micrograms per liter; mg/L, milligrams per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Sample ID	Site No.	Split	Sample type	Job. No. ICP-AES & ICP-MS	Lab No. ICP-AES & ICP-MS	Ag (µg/L) ICP-AES	Al (µg/L) ICP-AES	As (µg/L) ICP-AES	B (µg/L) ICP-AES	Ba (µg/L) ICP-AES
Field Blanks										
06Ely-Q-1 FA	—	filtered	blank	MRP-07541	C-289442	<5	<20	<200	<5	<1
06Ely-Q-1 RA	—	raw	blank	MRP-07541	C-289443	<5	<20	<200	<5	<1
06Ely-Q-2 FA	—	filtered	blank	MRP-07541	C-289444	<5	<20	<200	<5	<1
06Ely-Q-2 RA	—	raw	blank	MRP-07541	C-289445	<5	<20	<200	<5	<1
Replicates										
06Ely19A-R FA	SB-3125M	filtered	surface-water replicate	MRP-07543	C-289521	<5	107	<200	<5	20
06Ely19A-R RA	SB-3125M	raw	surface-water replicate	MRP-07543	C-289522	<5	342	<200	<5	20
06Ely06B-R FA	SB-2400M	filtered	pore-water (in situ) replicate	MRP-07543	C-289541	<5	<20	<200	<5	29
06Ely06B-R RA	SB-2400M	raw	pore-water (in situ) replicate	MRP-07543	C-289542	<5	33	<200	<5	29
06Ely08C-R FA	SB-140M	filtered	pore-water (centrifuge) replicate	MRP-07596	C-290558	<5	36	<200	5.8	43
06Ely08RD FA	SB-140M	filtered	pore-water (equilibrated) replicate	MRP-07596	C-290559	<5	<20	<200	7.8	104
Reference waters as unknowns										
FL-control FA	—	filtered	control	MRP-07596	C-290564	<5	1,530	<200	70	665
M-150	—	—	reference water	MRP-07541	C-289452	<5	<20	<200	<5	21
M-150	—	—	reference water	MRP-07596	C-290536	<5	<20	<200	<5	22
M-158	—	—	reference water	MRP-07543	C-289547	<5	<20	<200	23	22
M-158	—	—	reference water	MRP-07596	C-290547	<5	<20	<200	25	20
T-135	—	—	reference water	MRP-07543	C-289559	9.7	<20	<200	11	67
T-135	—	—	reference water	MRP-07596	C-290566	16	<20	<200	11	65
T-137	—	—	reference water	MRP-07543	C-289558	<5	<20	<200	15	65
T-137	—	—	reference water	MRP-07596	C-290565	<5	29	<200	16	64
Reference waters standard results[a]										
M-150	—	—	reference-water results	—	—	—	—	—	—	—
M-158	—	—	reference-water results	—	—	—	—	—	23.4±3.45	—
T-135	—	—	reference-water results	—	—	9.81±1.05	10.5±6.8	10.0±1.1	—	67.8±4.3
T-137	—	—	reference-water results	—	—	—	30.5±6.9	—	—	65.0±4.8

[μg/L, micrograms per liter; mg/L, milligrams per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Sample ID	Be (μg/L) ICP-AES	Ca (mg/L) ICP-AES	Cd (μg/L) ICP-AES	Co (μg/L) ICP-AES	Cr (μg/L) ICP-AES	Cu (μg/L) ICP-AES	Fe (μg/L) ICP-AES	K (mg/L) ICP-AES	Li (μg/L) ICP-AES	Mg (mg/L) ICP-AES	Mn (μg/L) ICP-AES	Mo (μg/L) ICP-AES	Ni (μg/L) ICP-AES	P (mg/L) ICP-AES
Field Blanks														
06Ely-Q-1 FA	<10	<0.1	<5	<10	<10	<10	<20	<0.1	<5	<0.1	<10	<20	<10	<0.5
06Ely-Q-1 RA	<10	<0.1	<5	<10	<10	<10	<20	<0.1	<5	<0.1	<10	<20	<10	<0.5
06Ely-Q-2 FA	<10	<0.1	<5	<10	<10	<10	<20	<0.1	<5	<0.1	<10	<20	<10	<0.5
06Ely-Q-2 RA	<10	<0.1	<5	<10	<10	<10	<20	<0.1	<5	<0.1	<10	<20	<10	<0.5
Replicates														
06Ely19A-R FA	<10	35.2	<5	<10	<10	41	34	2.37	<5	2	44	<20	<10	<0.5
06Ely19A-R RA	<10	35.7	<5	<10	<10	117	373	2.41	<5	2.02	48	<20	<10	<0.5
06Ely06B-R FA	<10	46.7	<5	<10	<10	<10	<20	4.12	<5	3.21	117	<20	<10	<0.5
06Ely06B-R RA	<10	46.8	<5	<10	<10	11	32	4.09	<5	3.22	118	<20	<10	<0.5
06Ely08C-R FA	<10	60.5	<5	<10	<10	14	36	3.88	<5	3.26	42	<20	<10	<0.5
06Ely08RD FA	<10	125	<5	12	<10	46	<20	8.38	<5	6.91	3,980	<20	<10	<0.5
Reference waters as unknowns														
FL-control FA	<10	372	<5	<10	<10	<10	1020	7.04	11	82.7	11,000	<20	29	<0.5
M-150	<10	6.9	<5	<10	<10	<10	<20	1.11	<5	1.45	<10	<20	<10	<0.5
M-150	<10	6.83	<5	<10	<10	<10	<20	1.14	<5	1.47	<10	<20	<10	<0.5
M-158	<10	38.3	<5	<10	<10	<10	<20	1.66	<5	12	<10	<20	<10	<0.5
M-158	<10	38.1	<5	<10	<10	<10	<20	1.65	<5	12	<10	<20	<10	<0.5
T-135	57	10.3	53	44	83	62	210	0.92	76	2.06	436	47	69	<0.5
T-135	57	10.4	54	44	83	64	201	0.92	75	2.09	432	45	69	<0.5
T-137	<10	37.8	7.1	<10	21	<10	58	1.1	8.8	9.84	97	<20	15	<0.5
T-137	<10	36.7	7	<10	19	<10	49	1.11	8.8	10.1	95	<20	14	<0.5
Reference waters standard results														
M-150	—	6.82±0.41	—	—	—	—	—	1.12±0.09	—	1.43±0.09	—	—	—	—
M-158	—	38.1±1.59	—	—	—	—	—	1.71±0.119	—	11.8±0.48	—	—	—	0.190±0.013
T-135	59.0±2.6	10.4±0.6	50.5±3.2	40.0±2.6	79.0±5.5	62.0±4.2	228±11	0.96±0.09	73.7±5.2	2.00±0.09	423±20	63.0±5.1	65.6±5.0	—
T-137	5.2±0.5	38.1±1.5	6.80±0.52	—	19.4±2.0	1.9±1.2	71±9	1.19±0.13	8.7±1.5	10.1±0.5	98±5	8.9±1.8	15.0±2.5	—

Appendix 2. Quality-assurance, quality-control water samples for the Ely Mine study, Vershire, VT.—Continued

[µg/L, micrograms per liter; mg/L, milligrams per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Sample ID	Pb (µg/L) ICP-AES	Sb (µg/L) ICP-AES	SiO_2 (mg/L) ICP-AES	SO_4 (mg/L) ICP-AES	Sr (µg/L) ICP-AES	Ti (µg/L) ICP-AES	V (µg/L) ICP-AES	Zn (µg/L) ICP-AES	Ag (µg/L) ICP-MS	Al (µg/L) ICP-MS	As (µg/L) ICP-MS	Ba (µg/L) ICP-MS	Be (µg/L) ICP-MS	Bi (µg/L) ICP-MS
Field Blanks														
06Ely-Q-1 FA	<50	<50	<0.1	<1	<1	<50	<10	<20	<3	<2	<1	<0.2	<0.05	<0.2
06Ely-Q-1 RA	<50	<50	<0.1	<1	<1	<50	<10	<20	<3	<2	<1	<0.2	<0.05	<0.2
06Ely-Q-2 FA	<50	<50	<0.1	<1	<1	<50	<10	<20	<3	<2	<1	<0.2	<0.05	<0.2
06Ely-Q-2 RA	<50	<50	<0.1	<1	<1	<50	<10	<20	<3	<2	<1	<0.2	<0.05	<0.2
Replicates														
06Ely19A-R FA	<50	<50	9	17	175	<50	<10	<20	<3	94.9	<1	17.7	<0.05	<0.2
06Ely19A-R RA	<50	<50	9.3	17.2	178	<50	<10	24	<3	293	<1	18.4	<0.05	<0.2
06Ely06B-R FA	<50	<50	10.3	20.7	220	<50	<10	<20	<3	13	<1	27.1	<0.05	<0.2
06Ely06B-R RA	<50	<50	10.3	20.7	220	<50	<10	<20	<3	34	<1	26.7	<0.05	<0.2
06Ely08C-R FA	<50	<50	9.8	34.2	268	<50	<10	<20	<3	24.4	<1	36.4	<0.05	<0.2
06Ely08RD FA	<50	<50	16.3	92.2	576	<50	<10	<20	<3	11.8	<1	93.2	<0.05	<0.2
Reference waters as unknowns														
FL-control FA	<50	<50	27.6	71.8	1,250	55	15	27	<3	1,100	3.3	581	0.05	<0.2
M-150	<50	<50	13.9	5.6	53	<50	25	<20	<3	3.2	<1	6.86	<0.05	<0.2
M-150	<50	<50	13.8	5.6	50	<50	23	<20	<3	4.3	<1	9.19	0.05	<0.2
M-158	<50	<50	16.3	106	62	<50	<10	<20	<3	<2	<1	8.47	<0.05	<0.2
M-158	<50	<50	16.7	109	62	<50	<10	<20	<3	<2	<1	6.6	<0.05	<0.2
T-135	109	76	4.7	6.6	46	<50	53	46	8.95	8.6	9.5	57.6	56.9	<0.2
T-135	111	79	5	6.8	44	<50	53	46	8.14	6.8	8.1	53.1	52.4	<0.2
T-137	<50	<50	7.7	49.9	236	<50	13	48	<3	19.7	<1	55.7	4.7	<0.2
T-137	<50	<50	7.7	50	215	<50	12	48	<3	21.8	<1	51.1	4.6	<0.2
Reference waters standard results														
M-150	—	—	12.6±0.8	5.50±0.54	51.0±2.5	—	31.0±1.9	—	—	—	—	—	—	—
M-158	—	—	15.0±0.67	105±3.7	63.6±1.85	—	11.3±0.82	—	—	—	—	—	—	—
T-135	103±7	76.3±8.7	4.28±0.31	—	46.0±2.3	—	52.8±3.6	48.2±4.7	9.81±1.05	10.5±6.8	10.0±1.1	67.8±4.3	59.0±2.6	—
T-137	6.3±1.0	15.5±2.7	6.96±0.56	—	230±14	—	14.0±1.6	49.5±4.2	—	30.5±6.9	—	65.0±4.8	5.2±0.5	—

Appendix 2. Quality-assurance, quality-control water samples for the Ely Mine study, Vershire, VT.—Continued

[µg/L, micrograms per liter; mg/L, milligrams per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Sample ID	Ca (mg/L) ICP-MS	Cd (µg/L) ICP-MS	Ce (µg/L) ICP-MS	Co (µg/L) ICP-MS	Cr (µg/L) ICP-MS	Cs (µg/L) ICP-MS	Cu (µg/L) ICP-MS	Dy (µg/L) ICP-MS	Er (µg/L) ICP-MS	Eu (µg/L) ICP-MS	Fe (µg/L) ICP-MS	Ga (µg/L) ICP-MS	Gd (µg/L) ICP-MS	Ge (µg/L) ICP-MS	Ho (µg/L) ICP-MS
Field Blanks															
06Ely-Q-1 FA	<0.2	<0.02	<0.01	<0.02	<1	<0.02	<0.5	<0.005	<0.005	<0.005	<50	<0.05	<0.005	<0.05	<0.005
06Ely-Q-1 RA	<0.2	<0.02	<0.01	<0.02	<1	<0.02	<0.5	<0.005	<0.005	<0.005	<50	<0.05	<0.005	<0.05	<0.005
06Ely-Q-2 FA	<0.2	<0.02	<0.01	<0.02	<1	<0.02	<0.5	<0.005	<0.005	<0.005	<50	<0.05	<0.005	<0.05	<0.005
06Ely-Q-2 RA	<0.2	<0.02	<0.01	<0.02	<1	<0.02	<0.5	<0.005	<0.005	<0.005	<50	<0.05	<0.005	<0.05	<0.005
Replicates															
06Ely19A-R FA	30.7	0.12	0.22	4.04	<1	0.13	38.6	0.02	0.006	0.005	<50	<0.05	0.03	<0.05	<0.005
06Ely19A-R RA	31	0.14	1.52	4.26	<1	0.14	112	0.12	0.05	0.04	345	<0.05	0.18	<0.05	0.02
06Ely06B-R FA	45.6	0.07	0.02	0.31	<1	0.15	8.4	<0.005	<0.005	<0.005	<50	<0.05	<0.005	<0.05	<0.005
06Ely06B-R RA	44.4	0.07	0.08	0.33	<1	0.15	12.3	0.009	<0.005	0.007	<50	<0.05	0.01	<0.05	<0.005
06Ely08C-R FA	52.3	0.21	0.08	0.73	<1	0.16	14.4	0.006	<0.005	0.007	<50	<0.05	0.01	<0.05	<0.005
06Ely08RD FA	112	0.37	0.13	9.93	<1	0.55	44.7	0.01	0.007	0.02	<50	0.09	0.01	<0.05	<0.005
Reference waters as unknowns															
FL-control FA	342	1.28	2.21	8.31	2.9	0.1	6.4	0.29	0.16	0.18	895	0.51	0.38	<0.05	0.051
M-150	5.59	<0.02	0.01	0.02	<1	<0.02	<0.5	<0.005	<0.005	<0.005	<50	<0.05	<0.005	<0.05	<0.005
M-150	6.5	<0.02	0.01	0.02	1.3	<0.02	<0.5	<0.005	<0.005	<0.005	<50	<0.05	<0.005	<0.05	<0.005
M-158	34.6	<0.02	<0.01	<0.02	3.1	<0.02	<0.5	<0.005	<0.005	<0.005	<50	<0.05	<0.005	<0.05	<0.005
M-158	27.8	<0.02	<0.01	<0.02	3.1	<0.02	<0.5	<0.005	<0.005	<0.005	<50	<0.05	<0.005	<0.05	<0.005
T-135	9.07	51.7	0.03	36.8	71	<0.02	59.8	0.005	<0.005	0.007	162	<0.05	0.01	<0.05	<0.005
T-135	8.28	44.3	0.03	31	59.9	<0.02	50.4	<0.005	0.005	0.008	119	<0.05	0.008	<0.05	<0.005
T-137	30.5	6.77	0.05	0.14	16.6	0.02	1.7	0.009	0.007	0.006	<50	<0.05	0.01	<0.05	<0.005
T-137	29.3	5.98	0.04	0.14	14.6	<0.02	1.5	0.006	0.006	0.01	<50	<0.05	0.007	<0.05	<0.005
Reference waters standard results															
M-150	6.82±0.41	—	—	—	—	—	—	—	—	—	—	—	—	—	—
M-158	38.1±1.59	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T-135	10.4±0.6	50.5±3.2	—	40.0±2.6	79.0±5.5	—	62.0±4.2	—	—	—	228±11	—	—	—	—
T-137	38.1±1.5	6.80±0.52	—	—	19.4±2.0	—	1.9±1.2	—	—	—	71±9	—	—	—	—

Appendix 2. Quality-assurance, quality-control water samples for the Ely Mine study, Vershire, VT.—Continued

[µg/L, micrograms per liter; mg/L, milligrams per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Sample ID	K (mg/L) ICP-MS	La (µg/L) ICP-MS	Li (µg/L) ICP-MS	Lu (µg/L) ICP-MS	Mg (mg/L) ICP-MS	Mn (µg/L) ICP-MS	Mo (µg/L) ICP-MS	Na (mg/L) ICP-MS	Nb (µg/L) ICP-MS	Nd (µg/L) ICP-MS	Ni (µg/L) ICP-MS	P (mg/L) ICP-MS	Pb (µg/L) ICP-MS	Pr (µg/L) ICP-MS	Sb (µg/L) ICP-MS
Field Blanks															
06Ely-Q-1 FA	<0.03	<0.01	0.2	<0.1	<0.01	<0.2	<2	<0.01	<0.2	<0.01	<0.4	<0.01	0.7	<0.01	<0.3
06Ely-Q-1 RA	<0.03	<0.01	0.3	<0.1	<0.01	<0.2	<2	0.01	<0.2	<0.01	<0.4	<0.01	<0.05	<0.01	<0.3
06Ely-Q-2 FA	<0.03	<0.01	0.2	<0.1	<0.01	<0.2	<2	<0.01	<0.2	<0.01	<0.4	<0.01	<0.05	<0.01	<0.3
06Ely-Q-2 RA	<0.03	<0.01	0.2	<0.1	<0.01	<0.2	<2	<0.01	<0.2	<0.01	<0.4	<0.01	<0.05	<0.01	<0.3
Replicates															
06Ely19A-R FA	2.13	0.12	1.6	<0.1	1.7	40.5	<2	3.62	<0.2	0.13	3.2	<0.01	0.2	0.03	<0.3
06Ely19A-R RA	2.11	0.75	1.6	<0.1	1.69	44	<2	3.59	<0.2	0.86	1.5	<0.01	0.08	0.21	<0.3
06Ely06B-R FA	4.18	0.03	1.6	<0.1	3.21	115	<2	16	<0.2	0.03	0.5	<0.01	<0.05	<0.01	<0.3
06Ely06B-R RA	4.1	0.06	1.5	<0.1	3.14	113	<2	15.6	<0.2	0.06	0.4	<0.01	<0.05	0.02	<0.3
06Ely08C-R FA	3.45	0.05	1	<0.1	2.73	35.2	<2	5.55	<0.2	0.05	2.1	<0.01	0.1	0.01	<0.3
06Ely08RD FA	7.42	0.08	2.2	<0.1	6.07	3,570	<2	9.4	<0.2	0.06	4.2	<0.01	0.2	0.02	<0.3
Reference waters as unknowns															
FL-control FA	5.95	1.57	7.2	<0.1	66.9	9,810	<2	14.8	<0.2	1.8	34.4	0.3	0.63	0.39	0.41
M-150	0.96	0.01	0.8	<0.1	1.19	1.8	<2	14.7	<0.2	<0.01	<0.4	<0.01	0.09	<0.01	<0.3
M-150	1.1	<0.01	1.6	<0.1	1.27	2	<2	16.5	<0.2	0.01	<0.4	<0.01	<0.05	<0.01	<0.3
M-158	1.58	<0.01	1.2	<0.1	10.4	<0.2	2.1	64.8	0.94	<0.01	<0.4	0.2	0.05	<0.01	0.9
M-158	1.18	<0.01	0.5	<0.1	7.07	<0.2	<2	43.5	0.26	<0.01	<0.4	0.1	<0.05	<0.01	<0.3
T-135	0.77	0.03	71.5	<0.1	1.55	386	54.4	24	<0.2	0.03	60.2	0.02	100	<0.01	78.7
T-135	0.72	0.02	63.9	<0.1	1.48	325	44.1	23.7	<0.2	0.03	51.5	0.02	89.1	<0.01	69
T-137	0.87	0.04	6.8	<0.1	6.64	86.8	6.3	14.6	<0.2	0.03	13.5	0.03	5.9	<0.01	15.8
T-137	0.87	0.03	7.9	<0.1	7.54	77.4	5.5	16.1	<0.2	0.03	12.8	0.04	5.1	<0.01	14.4
Reference waters standard results															
M-150	1.12±0.09	—	—	—	1.43±0.09	—	—	17.5±1.0	—	—	—	—	—	—	—
M-158	1.71±0.119	—	—	—	11.8±0.48	—	—	71.7±2.22	—	—	—	0.190±0.013	—	—	—
T-135	0.96±0.09	—	73.7±5.2	—	2.00±0.09	423±20	63.0±5.1	30.8±1.2	—	—	65.6±5.0	—	103±7	—	76.3±8.7
T-137	1.19±0.13	—	8.7±1.5	—	10.1±0.5	98±5	8.9±1.8	22.0±1.1	—	—	15.0±2.5	—	6.3±1.0	—	15.5±2.7

Appendix 2. Quality-assurance, quality-control water samples for the Ely Mine study, Vershire, VT.—Continued

[µg/L, micrograms per liter; mg/L, milligrams per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Sample ID	Sc (µg/L) ICP-MS	Se (µg/L) ICP-MS	SiO_2 (mg/L) ICP-MS	Sm (µg/L) ICP-MS	SO_4 (mg/L) ICP-MS	Sr (µg/L) ICP-MS	Ta (µg/L) ICP-MS	Tb (µg/L) ICP-MS	Ti (µg/L) ICP-MS	Tl (µg/L) ICP-MS	Tm (µg/L) ICP-MS	U (µg/L) ICP-MS	V (µg/L) ICP-MS	W (µg/L) ICP-MS	Y (µg/L) ICP-MS
Field Blanks															
06Ely-Q-1 FA	<0.6	<1	<0.2	<0.01	<2	<0.5	<0.02	<0.005	<0.5	<0.1	<0.005	<0.1	<0.5	<0.5	<0.01
06Ely-Q-1 RA	<0.6	<1	<0.2	<0.01	<2	<0.5	<0.02	<0.005	<0.5	<0.1	<0.005	<0.1	<0.5	<0.5	<0.01
06Ely-Q-2 FA	<0.6	<1	<0.2	<0.01	<2	<0.5	<0.02	<0.005	<0.5	<0.1	<0.005	<0.1	<0.5	<0.5	<0.01
06Ely-Q-2 RA	<0.6	<1	<0.2	<0.01	<2	<0.5	<0.02	<0.005	<0.5	<0.1	<0.005	<0.1	<0.5	<0.5	<0.01
Replicates															
06Ely19A-R FA	0.8	<1	7	0.01	14	158	<0.02	<0.005	<0.5	<0.1	<0.005	0.3	<0.5	<0.5	0.07
06Ely19A-R RA	0.8	<1	7.2	0.17	14	158	<0.02	0.02	1.1	<0.1	0.005	0.32	<0.5	<0.5	0.44
06Ely06B-R FA	0.9	<1	9.4	<0.01	21	215	<0.02	<0.005	<0.5	<0.1	<0.005	0.33	<0.5	<0.5	0.03
06Ely06B-R RA	0.9	<1	9.3	0.01	21	209	<0.02	<0.005	1.3	<0.1	<0.005	0.33	<0.5	<0.5	0.04
06Ely08C-R FA	1.1	1	7.5	<0.01	30	238	<0.02	<0.005	1	<0.1	<0.005	0.35	<0.5	<0.5	0.04
06Ely08RD FA	1.8	1	12.8	0.01	85	527	<0.02	<0.005	1.2	<0.1	<0.005	1.09	<0.5	<0.5	0.1
Reference waters as unknowns															
FL-control FA	3.5	9.5	20.5	0.36	54	1,140	<0.02	0.05	42	0.1	0.02	0.12	15	<0.5	1.41
M-150	0.9	<1	10.6	<0.01	2	46.3	0.24	<0.005	1.1	<0.1	<0.005	<0.1	20.8	3.36	0.01
M-150	1.5	<1	11.8	<0.01	7	46.6	<0.02	<0.005	<0.5	<0.1	<0.005	<0.1	22.5	2.38	<0.01
M-158	1.4	<1	13.2	<0.01	97	60.4	0.38	<0.005	1.8	<0.1	<0.005	<0.1	7.9	6.68	<0.01
M-158	1.2	<1	9.4	<0.01	79	54.2	<0.02	<0.005	1.1	<0.1	<0.005	<0.1	7.1	2.71	<0.01
T-135	<0.6	11.1	3.1	<0.01	3	45.2	<0.02	<0.005	<0.5	0.1	<0.005	0.24	47.9	<0.5	0.02
T-135	<0.6	9.1	3.1	<0.01	4	36.6	<0.02	<0.005	<0.5	<0.1	<0.005	0.21	39.5	<0.5	0.02
T-137	<0.6	<1	4.5	<0.01	33	216	<0.02	<0.005	0.8	168	<0.005	8.67	11.3	<0.5	0.05
T-137	0.6	<1	5	<0.01	38	191	<0.02	<0.005	0.8	148	<0.005	7.24	10.1	<0.5	0.04
Reference waters standard results															
M-150	—	—	12.6±0.8	—	5.50±0.54	51.0±2.5	—	—	—	—	—	—	31.0±1.9	—	—
M-158	—	—	15.0±0.67	—	105±3.7	63.6±1.85	—	—	—	—	—	—	11.3±0.82	—	—
T-135	—	10.0±1.4	4.28±0.31	—	—	46.0±2.3	—	—	—	—	—	—	52.8±3.6	—	—
T-137	—	—	6.96±0.56	—	—	230±14	—	—	—	162±23	—	10.0±0.5	14.0±1.6	—	—

Appendix 2. Quality-assurance, quality-control water samples for the Ely Mine study, Vershire, VT.—Continued

[µg/L, micrograms per liter; mg/L, milligrams per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Sample ID	Yb (µg/L) ICP-MS	Zn (µg/L) ICP-MS	Zr (µg/L) ICP-MS	Job No. IC	Lab No. IC	Field No. IC	Cl (mg/L) IC	F (mg/L) IC	NO_3 (mg/L) IC	SO_4 (mg/L) IC	Job No. CVAF	Lab No. CVAF	Field No. CVAF	Hg (ng/L) CVAF
Field Blanks														
06Ely-Q-1 FA	<0.005	2.4	<0.2	MRP-07540	C-289423	06Ely-Q-1 FU	<0.08	<0.08	<0.08	26	MRP-07542	C-289499	06Ely-Q-1 Hg	<5
06Ely-Q-1 RA	<0.005	1.9	<0.2	—	—	—	—	—	—	—	—	—	—	—
06Ely-Q-2 FA	<0.005	0.6	<0.2	MRP-07540	C-289427	06Ely-Q-2 FU	<0.08	<0.08	<0.08	<0.08	MRP-07542	C-289503	06Ely-Q-2 Hg	<5
06Ely-Q-2 RA	<0.005	1.3	<0.2	—	—	—	—	—	—	—	—	—	—	—
Replicates														
06Ely19A-R FA	0.005	27	<0.2	MRP-07540	C-289426	06Ely19A-R FU	4.6	0.09	0.6	12	MRP-07542	C-289502	06Ely19A-R Hg	<5
06Ely19A-R RA	0.03	23.6	<0.2	—	—	—	—	—	—	—	—	—	—	—
06Ely06B-R FA	<0.005	7.4	<0.2	MRP-07540	C-289430	06Ely06B-R FU	21	<0.08	<0.08	21	MRP-07542	C-289506	06Ely06B-R Hg	<5
06Ely06B-R RA	<0.005	4	<0.2	—	—	—	—	—	—	—	—	—	—	—
06Ely08C-R FA	<0.005	4.4	<0.2	—	—	—	—	—	—	—	—	—	—	—
06Ely08RD FA	0.006	10	<0.2	MRP-07597	C-290581	06Ely08RD FU	7.5	0.3	1.8	82	—	—	—	—
Reference waters as unknowns														
FL-control FA	0.13	25.5	1.6	—	—	—	—	—	—	—	—	—	—	—
M-150	<0.005	0.8	0.2	MRP-07540	C-289412	M-150	17	0.9	8.2	5.6	—	—	—	—
M-150	<0.005	0.7	<0.2	MRP-07597	C-290584	M-150	18	1	<0.08	5.8	—	—	—	—
M-158	<0.005	<0.5	<0.2	MRP-07540	C-289413	M-158	88.5	0.4	1.4	104	—	—	—	—
M-158	<0.005	<0.5	<0.2	MRP-07597	C-290585	M-158	91.1	0.45	1.6	106.5	—	—	—	—
T-135	0.005	49.7	<0.2	—	—	—	—	—	—	—	—	—	—	—
T-135	0.005	40.9	<0.2	—	—	—	—	—	—	—	—	—	—	—
T-137	0.007	47.9	<0.2	—	—	—	—	—	—	—	—	—	—	—
T-137	0.008	41.8	<0.2	—	—	—	—	—	—	—	—	—	—	—
Reference waters standard results														
M-150	—	—	—	—	—	M-150	17.0±1.5	1.00±0.07	—	5.50±0.54	—	—	—	—
M-158	—	—	—	—	—	M-158	90.7±2.74	0.350±0.045	—	105±3.7	—	—	—	—
T-135	—	48.2±4.7	—	—	—	T-135	—	—	—	—	—	—	—	—
T-137	—	49.5±4.2	—	—	—	T-137	—	—	—	—	—	—	—	—

[a] Round robin results with one standard deviation.

Appendix 3. Quality-assurance, quality-control sediment samples for the Ely Mine study, Vershire, VT.

[wt. %, weight percent; mg/kg, milligrams per kilogram; —, not determined; <, analyte not detected at the reporting level]

Sample ID	Site No.	Sample type	Job No.	Lab No.	Al (wt. %)	Ca (wt. %)	Fe (wt. %)	K (wt. %)
Field Blanks								
Blank	—	blank	—	—	<0.01	<0.01	<0.01	<0.01
Replicates								
06Ely09	OR-24050M	lab replicate	—	DUP-C-290598	3.38	1.16	1.48	0.82
06Ely02-2	EB-770M	lab replicate	MRP-07598	C-290588	5.01	1.33	5.84	1.1
06Ely04-RD	EB-90M	field replicate with bottle sampler	MRP-07598	C-290591	3.44	0.89	16.9	0.86
06Ely08R	SB-140M	field replicate	MRP-07598	C-290597	3.66	1.32	2.42	0.87
Reference materials as unknowns								
SO-3	—	reference material	—	—	3.09	14.4	1.51	1.35
NBS88B	—	reference material	—	—	—	—	—	—
SO-2	—	reference material	—	—	—	—	—	—
NIST8603	—	reference material	—	—	—	—	—	—
SARL.1	—	reference material	MRP-07599	C-290608	5.35	0.94	2.48	2.96
SARM.1	—	reference material	MRP-07599	C-290609	5.45	0.5	2.98	2.97
Reference material standard results[a]								
SO-3	—	certified value with 95% confidence interval	—	—	3.05 ± 0.11	14.63 ± 0.4	1.51 ± 0.06	1.61 ± 0.05
NBS88B	—	NBS88B certified value with two standard deviations	—	—	—	—	—	—
SO-2	—	certified value with 95% confidence interval	—	—	—	—	—	—
NIST8603	—	NIST8603 reference concentration with 95% confidence interval	—	—	—	—	—	—
SARL.1	—	reference sample mean values	—	—	5.84	1.06	2.6	3.02
SARM.1	—	reference sample mean values	—	—	6.13	0.59	3.10	2.88

Appendix 3. Quality-assurance, quality-control sediment samples for the Ely Mine study, Vershire, VT. —Continued

[wt. %, weight percent; mg/kg, milligrams per kilogram; —, not determined; <, analyte not detected at the reporting level]

Sample ID	Mg (wt. %)	Na (wt. %)	S (wt. %)	Ti (wt. %)	Ag (mg/kg)	As (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Bi (mg/kg)	Cd (mg/kg)	Ce (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cs (mg/kg)	Cu (mg/kg)	Ga (mg/kg)	Hg (mg/kg)
Field Blanks																	
Blank	<0.01	<0.01	<0.01	<0.01	<1	<1	<5	<0.1	<0.04	<0.1	<0.05	<0.1	<1	<5	<0.5	<0.05	<0.02
Replicates																	
06Ely09	0.78	0.75	0.02	0.16	<1	4	190	1.6	0.08	<0.1	16.3	6.4	39	<5	5	7.66	<0.02
06Ely02-2	1.04	1.12	0.3	0.38	<1	4	239	1.6	0.34	0.6	28.9	22.4	65	<5	1,230	11.9	<0.02
06Ely04-RD	0.65	0.91	1.86	0.26	3	6	152	1	1.55	0.6	9.6	15.3	62	<5	5,970	9.59	<0.02
06Ely08R	0.7	0.78	0.07	0.19	<1	1	199	1.5	0.18	0.2	21.5	12.1	29	<5	255	8.1	<0.02
Reference materials as unknowns																	
SO-3	5.12	0.75	0.02	0.15	<1	3	286	0.8	0.07	0.2	32.7	5.2	26	<5	17.2	6.55	—
NBS88B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SO-2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.09
NIST8603	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SARL.1	0.51	1.38	0.09	0.21	3	16	907	3	133	489	0.99	3.1	147	6.6	75	<5	0.18
SARM.1	0.44	1.09	0.16	0.24	3	40	789	2.2	64	1020	1.75	5.7	110	10.2	78	<5	0.13
Reference material standard results																	
SO-3	4.98 ± 0.1	0.74 ± 0.04	—	0.2 ± 0.02	—	—	296 ± 39	—	—	—	—	8 ± 3	26 ± 3	—	17 ± 1	—	—
NBS88B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SO-2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.082 ± 0.009
NIST8603	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SARL.1	0.535	1.51	0.078	0.23	3.04	16.3	910	3.65	137	457	1.19	2.95	154	7.14	95.9	4.16	0.175
SARM.1	0.49	1.16	0.12	0.27	3.64	38.8	801	2.16	67.2	930	1.94	5.27	122	10.7	79.7	5.15	0.130

Appendix 3. Quality-assurance, quality-control sediment samples for the Ely Mine study, Vershire, VT. —Continued

[wt. %, weight percent; mg/kg, milligrams per kilogram; —, not determined; <, analyte not detected at the reporting level]

Sample ID	In (mg/kg)	La (mg/kg)	Li (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Nb (mg/kg)	Ni (mg/kg)	P (mg/kg)	Pb (mg/kg)	Rb (mg/kg)	Sb (mg/kg)	Sc (mg/kg)	Se (mg/kg)	Sn (mg/kg)	Sr (mg/kg)	Te (mg/kg)	Th (mg/kg)	Tl (mg/kg)
Field Blanks																		
Blank	<0.02	<0.5	<1	<5	<0.05	<0.1	<0.5	<50	<0.5	<0.2	<0.05	<0.1	<0.2	<0.1	<0.5	<0.1	<0.2	<0.1
Replicates																		
06Ely09	0.02	9.3	31	495	0.21	3.8	12.5	270	10.6	43.8	0.22	5.2	<0.2	1.1	206	<0.1	3	0.2
06Ely02-2	0.08	15.2	23	2,200	3.91	5.2	20.2	360	15	49.4	0.37	16.5	3.9	1.4	116	0.2	4.1	0.3
06Ely04-RD	0.25	5.4	9	2,080	21	3.3	8.5	120	30.8	33.7	0.29	11.6	31.7	1.9	57.7	1	2.3	0.3
06Ely08R	0.03	11.2	24	784	1.76	4.7	12.1	280	24	43.1	1.35	9.5	1.2	1.2	187	<0.1	3.6	0.2
Reference materials as unknowns																		
SO-3	0.03	16.6	13	525	1.12	4.3	13.5	500	12.9	36	0.26	4.8	—	0.8	226	<0.1	3.6	0.2
NBS88B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SO-2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NIST8603	—	—	—	—	—	—	—	—	—	—	—	—	0.7	—	—	—	—	—
SARL.1	363	15.9	0.32	66.3	27	14.8	37.1	1,970	505	126	5.14	8.2	0.8	5.2	54.4	0.9	17.8	1.1
SARM.1	321	15.4	1.11	50.8	26	14.3	32.4	5,050	852	139	7.4	9	0.3	2.7	43	1.1	17	2.7
Reference material standard results																		
SO-3	—	—	—	520±20	—	—	—	480±50	14±3	39±3	—	—	—	—	217±29	—	—	—
NBS88B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SO-2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NIST8603	—	—	—	—	—	—	—	—	—	—	—	—	0.81±0.08	—	—	—	—	—
SARL.1	386	16.5	0.295	70.5	26.4	13.7	29.4	2,190	589	140	4.91	7.51	0.868	4.4	53	0.58	18.7	1.35
SARM.1	331	16.8	1.08	57.4	27.4	13.1	29.9	5,220	982	146	6.36	7.83	0.386	2.76	41.5	0.98	17.2	2.88

Appendix 3. Quality-assurance, quality-control sediment samples for the Ely Mine study, Vershire, VT. —Continued

[wt. %, weight percent; mg/kg, milligrams per kilogram; -, not determined; <, analyte not detected at the reporting level]

Sample ID	U (mg/kg)	V (mg/kg)	W (mg/kg)	Y (mg/kg)	Zn (mg/kg)	Carbonate (wt. % as C)	CO_2 (wt. % as C)	Total C (wt. % as C)
Field Blanks								
Blank	<0.1	<1	<0.1	<0.1	<1	—	<0.01	n.a.
Replicates								
06Ely09	0.8	40	0.4	8	37	—	0.15	0.4
06Ely02-2	1.3	90	0.5	21.2	139	0.02	0.07	0.54
06Ely04-RD	0.7	102	0.5	11.8	144	0.02	0.07	0.28
06Ely08R	0.8	50	0.4	10.9	77	0.1	0.38	0.42
Reference materials as unknowns								
SO-3	1	35	0.5	14.2	48	—	—	6.7
NBS88B	—	—	—	—	—	—	46.4	—
SO-2	—	—	—	—	—	—	—	—
NIST8603	—	—	—	—	—	—	—	—
SARL.1	3.9	750	3.1	31.9	140	0.1	0.37	1.04
SARM.1	3	700	9.1	23.6	138	0.02	0.08	0.33
Reference material standard results								
SO-3	—	38±6	—	—	52±3	—	—	—
NBS88B	—	—	—	—	—	—	46.37±0.12	—
SO-2	—	—	—	—	—	—	—	—
NIST8603	—	—	—	—	—	—	—	—
SARL.1	4.220	830	3.09	38.2	156	0.102	0.378	1.06
SARM.1	3.57	775	9.78	28.0	151	0.020	0.082	0.35

[a] Round robin results with one standard deviation.

Appendix 4. Acid volatile sulfide (AVS), simultaneously extractable metals (SEM), and particle-size results for stream sediments and quality-assurance, quality-control samples for the Ely Mine study area, Vershire, VT.

[%, percent; mg/kg, milligrams per kilogram; µmol/g, micromoles per gram; µm, micrometer; —, not determined; <, analyte not detected at the reporting level]

Site No.	Sample ID	Sample description	Solids[a] (%)	ASS[b] (mg/kg)	AVS[c] (µmol/g)	SEM[d]							
						Cd (µmol/g)	Cu (µmol/g)	Fe (µmol/g)	Pb (µmol/g)	Mn (µmol/g)	Ni (µmol/g)	Zn (µmol/g)	Hg (µmol/g)
Samples													
EB-1080M	06ELY01	stream sediment	72.3	<10.9	<0.67	<0.0012	0.2	53.4	0.013	4.1	0.048	0.2	<0.0009
EB-770M	06ELY02	stream sediment	76.5	<10.5	<0.64	0.0012	5.4	48.3	0.011	2.1	0.036	0.3	<0.0008
EB-600M	06ELY03	stream sediment	79.4	<10.1	<0.61	0.0036	13.8	39.4	0.017	4.8	0.055	0.65	<0.00075
EB-90M	06ELY04	stream sediment	75.7	<10.2	<0.63	<0.0012	1.1	124.4	0.019	0.1	0.013	0.052	<0.0008
SB-3670M	06ELY05	stream sediment	68.8	<11.6	<0.71	<0.0012	0.024	33.3	0.013	3.6	0.039	0.12	<0.0009
SB-2400M	06ELY06	stream sediment	77.9	<10.3	<0.64	<0.0012	0.99	39.8	0.0092	2.8	0.037	0.3	<0.0008
SB-1360M	06ELY07	stream sediment	74.9	<10.3	<0.65	<0.0012	1.0	35.8	0.0087	3.2	0.044	0.3	<0.0008
SB-140M	06ELY08	stream sediment	73.5	<10.8	<0.66	<0.0012	1.2	38.0	0.016	2.9	0.043	0.35	<0.00085
OR-24050M	06ELY09	stream sediment	72.8	<10.9	<0.69	<0.0012	0.017	25.6	0.014	2.4	0.036	0.11	<0.00085
OR-23200M	06ELY10	stream sediment	69.7	<11.5	<0.68	<0.0012	0.27	19.2	0.0068	1.9	0.026	0.14	<0.0009
Quality-assurance, quality-control samples													
SB-140M	06ELY08R	field duplicate	73	<10.9	<0.63	<0.0012	1.1	30.1	0.098	2.8	0.043	0.41	<0.0008
SB-1360M	06ELY07REP	lab replicate	73.6	<10.6	<0.65	<0.0012	1.5	30.6	0.01	2.8	0.04	0.28	<0.0008
SB-1360M	06ELY07MS	matrix spiked sample	-	63%[f]	74%	83.30%	84.50%	-	88.30%	-	85.10%	86.10%	52.40%
Blank	BLKSU082906B	lab blank	-	96%	-	-	-	-	-	-	-	-	-
Blank	BLK083106A	lab blank	-	92%	<0.5	<0.00089	<0.0087	<0.27	<0.0024	<0.003	<0.01	0.019	<0.0006
Spiked	LCS083106AMS	matrix spiked	-	-	-	89.7%	90.1%	-	92.9%	-	90.3%	90.5%	89.8%

Appendix 4. Acid volatile sulfide (AVS), simultaneously extractable metals (SEM), and particle-size results for stream sediments and quality-assurance, quality-control samples for the Ely Mine study area, Vershire, VT.—Continued

[%, percent; mg/kg, milligrams per kilogram; µmol/g, micromoles per gram; µm, micrometer; —, not determined; <, analyte not detected at the reporting level]

Site No.	SEM/AVS[e]	Particle size of soils (percent passing)[g]																
		1.4 µm (%)	3.2 µm (%)	3.3 µm (%)	3.4 µm (%)	6.6 µm (%)	6.7 µm (%)	6.8 µm (%)	7 µm (%)	9.2 µm (%)	9.3 µm (%)	9.4 µm (%)	9.5 µm (%)	9.6 µm (%)	9.7 µm (%)	13.2 µm (%)	13.3 µm (%)	13.4 µm (%)
Samples																		
EB-1080M	0	0.6	—	—	1	—	2	—	—	—	2	—	—	—	—	2.6	—	—
EB-770M	0	–0.4	—	—	–0.1	—	0.8	—	—	—	1.4	—	—	—	—	—	—	1.4
EB-600M	0	–0.3	—	–0.3	—	–0.3	—	—	—	—	—	—	—	—	0.3	—	—	0.8
EB-90M	0	0.1	—	0.3	—	—	—	0.8	—	—	—	—	—	1.4	—	—	—	1.4
SB-3670M	0	0.3	—	—	0.8	—	—	—	0.8	—	—	1.1	—	—	—	—	—	—
SB-2400M	0	0.2	—	—	0.7	0.7	—	—	—	—	—	—	1.3	—	—	—	—	1.8
SB-1360M	0	0.1	—	0.3	—	—	—	0.8	—	—	—	—	0.8	—	—	—	—	1.3
SB-140M	0	0.7	—	0.9	—	1.2	—	—	—	—	—	—	2	—	—	—	—	2
OR-24050M	0	0.9	1.6	—	—	—	—	1.6	—	—	2.5	—	—	—	—	—	—	2.5
OR-23200M	0	0.7	—	0.9	—	—	—	1.2	—	1.4	—	—	—	—	—	—	—	1.8
Quality-assurance, quality-control samples																		
SB-140M	0	0.3	—	—	0.8	—	—	—	0.8	—	—	—	—	0.8	—	—	—	—
SB-1360M	0	0.7	0.9	—	—	—	—	1.5	—	—	—	1.5	—	—	—	—	2	—
SB-1360M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Blank	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Blank	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Spiked	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Appendix 4. Acid volatile sulfide (AVS), simultaneously extractable metals (SEM), and particle-size results for stream sediments and quality-assurance, quality-control samples for the Ely Mine study area, Vershire, VT.—Continued

[%, percent; mg/kg, milligrams per kilogram; µmol/g, micromoles per gram; µm, micrometer; —, not determined; <, analyte not detected at the reporting level]

Site No.	Particle size of soils (percent passing)[g] (cont.)															
	13.5 µm (%)	23 µm (%)	36 µm (%)	37 µm (%)	75 µm (%)	150 µm (%)	180 µm (%)	250 µm (%)	425 µm (%)	850 µm (%)	2,000 µm (%)	4,750 µm (%)	9,500 µm (%)	19,000 µm (%)	25,000 µm (%)	37,500 µm (%)
Samples																
EB-1080M	—	2.6	3.1	—	6.7	12.9	16.4	26.2	43.3	69.9	93.7	99.1	100	100	100	100
EB-770M	—	1.9	1.9	—	12.3	17.2	19.3	24.9	34.4	47.8	62.2	79.3	89.6	100	100	100
EB-600M	—	0.8	—	0.8	12.2	13.4	14	16.5	23.3	39.5	62.8	86.5	99	100	100	100
EB-90M	—	1.4	2	—	5.5	8.6	11.1	18.1	29.2	42.5	58.7	88	100	100	100	100
SB-3670M	1.7	2.2	—	2.2	5.6	7.7	8.5	16.4	38.8	76.8	97.8	99.8	99.8	100	100	100
SB-2400M	—	1.8	—	1.8	12.7	14.1	14.8	19.1	28	44.2	64.5	84.1	96.4	100	100	100
SB-1360M	—	1.3	—	1.3	11	12.3	13.4	18.5	32.9	63	91.2	98.7	100	100	100	100
SB-140M	—	2	—	2	5.7	6.7	7.2	11.3	26.7	63.3	87.7	95.9	100	100	100	100
OR-24050M	—	2.5	—	2.5	5.7	11	12.9	27.5	59.9	86.4	95.4	99.6	100	100	100	100
OR-23200M	—	1.8	—	1.8	7.9	8.5	8.9	13.1	33	61.3	75.2	83.7	92.7	100	100	100
Quality-assurance, quality-control samples																
SB-140M	1.7	1.7	—	1.7	4.4	5.4	5.9	11.1	30	68	89.9	97.1	99.1	100	100	100
SB-1360M	—	2	2	—	6.3	7.6	8.8	14.1	29.1	59.8	89.1	98.5	100	100	100	100
SB-1360M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Blank	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Blank	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Spiked	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Appendix 4. Acid volatile sulfide (AVS), simultaneously extractable metals (SEM), and particle-size results for stream sediments and quality-assurance, quality-control samples for the Ely Mine study area, Vershire, VT.—Continued

[%, percent; mg/kg, milligrams per kilogram; µmol/g, micromoles per gram; µm, micrometer; —, not determined; <, analyte not detected at the reporting level]

Site No.	Soil fractions							
	50,000 µm (%)	75,000 µm (%)	Gravel (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Silt (%)	Clay (%)
Samples								
EB-1080M	100	100	0.9	5.4	50.4	36.7	4.7	2
EB-770M	100	100	20.7	17	27.8	22.1	11.5	0.8
EB-600M	100	100	13.5	23.7	39.5	11.1	12.4	–0.3
EB-90M	100	100	12	29.3	29.4	23.7	4.6	0.8
SB-3670M	100	100	0.2	2	59	33.2	4.8	0.8
SB-2400M	100	100	15.9	19.7	36.5	15.3	12	0.7
SB-1360M	100	100	1.3	7.5	58.3	21.9	10.2	0.8
SB-140M	100	100	4.1	8.2	60.9	21	4.5	1.2
OR-24050M	100	100	0.4	4.2	35.5	54.2	4.1	1.6
OR-23200M	100	100	16.3	8.5	42.2	25.1	6.7	1.2
Quality-assurance, quality-control samples								
SB-140M	100	100	2.9	7.2	59.9	25.6	3.6	0.8
SB-1360M	100	100	1.5	9.3	60.1	22.8	4.8	1.5
SB-1360M	—	—	—	—	—	—	—	—
Blank	—	—	—	—	—	—	—	—
Blank	—	—	—	—	—	—	—	—
Spiked	—	—	—	—	—	—	—	—

[a] Solids determined by Method IN623.

[b] Acid soluble sulfide (total sulfide) detemined by SW846 Method 9030B/9034.

[c] Acid volatile sulfide determined by SW846 Method 6010B.

[d] Simultaneously extractable metals detemined by SW846 Method 6010B(ICP-AES) for all metals except Hg, which was determined by Method 7471A (cold-vapor atomic absorption).

[e] SEM/AVS is the sum of the concentrations of all metals divided by AVS, which in this study was less than the detection limit.

[f] Recovery for spiked sample.

[g] Percentage of particles that passed through sieve size determined by ASTM D422.

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Ely Brook from river meter 0 to 350										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum[a]	87	16	16	15	16	7,900	3,830	491	4,690	5,100	4,000	2,750
Antimony[b]	104	14	6	0	10	0.13	*0.04*	*0.01*	*0.07*	0.06	*0.03*	*0.02*
Arsenic[c]	190	14	3	0	11	.51	*.15*	*.04*	*.22*	*.14*	*.08*	*.08*
Barium[b]	3.8	14	14	14	14	40	19	2.1	23	23	16	13
Beryllium[b]	5.09	14	11	0	14	.50	.18	.03	.23	.23	.16	.09
Cadmium[c, d]	1.1	14	14	12	14	4.70	2.27	.37	2.92	3.23	2.25	1.28
Chromium[c]	11	15	12	0	15	5.0	1.9	.3	2.5	2.4	1.4	1.0
Cobalt[b]	3.06	15	15	14	15	170	66.4	11.5	86.6	86.0	63.0	36.9
Copper[c, d]	11.8	15	15	14	15	3,400	1,580	218	1,960	1,900	1,560	1,270
Iron[c]	1,000	11	10	9	11	13,000	5,990	1,380	8,500	11,900	5,600	2,180
Lead[c, d]	3.2	15	9	0	13	.95	.38	.08	.52	.51	.28	*.22*
Manganese[b]	80.3	15	15	13	15	1,100	362	66	479	460	320	223
Mercury[a]	.012	8	1	1	3	.01						
Nickel[c, d]	158	15	15	0	15	36	17	2.4	21	23	17	11
Selenium[c]	5	15	8	0	12	.8	.5	.1	.6	.7	.5	.3
Silver[b]	.36	15	4	1	11	.40	*.04*	*.04*	*.10*	*.01*	*<.01*	*<.01*
Strontium[b]	620	13	13	0	13	120	63	8	78	80	60	40
Thallium[b]	18	15	4	0	12	.06	*.04*	*.003*	*.04*	*.05*	*.04*	*.03*
Uranium[b]	1.87	9	9	0	9	.68	.37	.07	.51	.53	.41	.18
Vanadium[b]	19.1	15	5	0	12	.20	*.10*	*.01*	*.12*	*.11*	*.09*	*.08*
Zinc[c, d]	106	15	15	13	15	590	290	40	360	391	300	182

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Ely Brook from river meter 350 to 540										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	13	13	13	13	34,000	9,010	2,790	14,000	8,700	5,000	3,750
Antimony	104	12	3	0	9	0.28	0.07	0.03	0.12	0.11	*0.03*	*0.01*
Arsenic	190	12	2	0	12	1.9	*.22*	*.16*	*.50*	*.08*	.02	.01
Barium	3.8	12	12	12	12	26	17	1.4	19	21	16	13
Beryllium	5.09	12	12	0	12	1.80	.47	.15	.74	.54	.25	.16
Cadmium	1.1	12	12	12	12	14	4.48	1.27	6.76	5.15	3.10	1.60
Chromium	11	12	12	2	12	32	7.6	3.3	14	7.5	2.8	2.0
Cobalt	3.06	12	12	12	12	630	167	61.1	276	195	80.5	44.9
Copper	11.8	12	12	12	12	6,500	2,420	485	3,290	2,520	2,050	1,300
Iron	1,000	8	8	8	8	74,600	31,300	10,300	50,700	62,200	17,600	7,180
Lead	3.2	12	10	0	12	1.40	.44	.11	.65	.46	.33	.18
Manganese	80.3	12	12	12	12	3,100	911	302	1,450	1,180	489	295
Mercury	.012	7	0									
Nickel	158	12	12	0	12	140	41	14	66	43	20	16
Selenium	5	12	8	0	12	1.0	.4	.1	.6	.6	.4	.2
Silver	.36	10	3	2	10	.15	.03	.01	.05	.03	.01	*<.01*
Strontium	620	12	12	0	12	170	73	14	98	78	64	39
Thallium	18	12	4	0	12	.11	*.05*	*.01*	*.07*	*.09*	*.04*	*.03*
Uranium	1.87	7	7	2	7	4.00	1.44	.56	2.52	3.10	.58	.49
Vanadium	19.1	12	9	0	9	3.00	.61	.32	1.19	.41	.10	.07
Zinc	106	12	12	12	12	2,300	702	207	1,070	740	385	311

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Ely Brook from river meter 540 to 800										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	6	6	5	6	17,900	3,380	2,910	9,250	5,460	445	140
Antimony	104	5	0									
Arsenic	190	5	0									
Barium	3.8	5	5	5	5	20	16	1.3	19	19	16	13
Beryllium	5.09	5	2	0	2	.06						
Cadmium	1.1	5	5	0	5	.95	.47	.14	.75	.73	.45	.21
Chromium	11	5	3	0	3	.10						
Cobalt	3.06	5	5	5	5	31.1	13.3	4.64	23.1	22.0	10.0	6.20
Copper	11.8	5	5	5	5	837	344	131	625	611	218	142
Iron	1,000	2	1	0	2	52						
Lead	3.2	5	2	0	2	.1						
Manganese	80.3	5	5	2	5	217	96.3	31.7	164	155	78.0	46.2
Mercury	.012	5	0									
Nickel	158	5	5	0	5	12	6.0	1.7	9.5	9.2	5.6	3.0
Selenium	5	5	1		1	.2						
Silver	.36	5	0									
Strontium	620	5	5	0	5	62	45	6	58	57	50	30
Thallium	18	5	0									
Uranium	1.87	2	1		2	.11						
Vanadium	19.1	5	3	0	3	.10						
Zinc	106	5	5	1	5	114	56	15	88	84	47	31

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Ely Brook above river meter 800										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	10	10	4	10	240	81	25	126	135	48	15
Antimony	104	10	3	0	7	0.31	*0.06*	*0.04*	*0.15*	*0.05*	*0.01*	*<0.01*
Arsenic	190	10	2	0	8	.40	*.12*	*.04*	*.20*	*.16*	*.08*	*.04*
Barium	3.8	10	10	10	10	30	19	1.6	22	22	18	15
Beryllium	5.09	10	0									
Cadmium	1.1	10	0									
Chromium	11	10	4	0	4	.2						
Cobalt	3.06	10	4	0	10	.14	*.05*	*.01*	*.08*	.09	*.03*	*.02*
Copper	11.8	10	8	0	10	6.9	*1.9*	*.6*	*3.0*	*1.9*	*1.4*	*1.1*
Iron	1,000	6	1	0	6	22						
Lead	3.2	10	3	0	8	.09	*.04*	*.009*	*.05*	*.05*	*.03*	*.02*
Manganese	80.3	10	10	2	10	124	22.4	14.3	48.5	24	1.75	.76
Mercury	.012	5	0									
Nickel	158	10	8	0	10	.7	.3	.1	.4	.5	.4	.1
Selenium	5	10	0									
Silver	.36	10	2	0	6	.03	*.01*	*.004*	*.02*	*.02*	*<.01*	*<.01*
Strontium	620	10	10	0	10	48	32	3	38	41	30	22
Thallium	18	10	0									
Uranium	1.87	6	5	0	5	.01	.01	.0005	.01	.01	.01	.01
Vanadium	19.1	10	4	0	9	.2	*.11*	*.01*	*.14*	*.14*	*.10*	*.09*
Zinc	106	10	10	0	10	33	12	3	18	22	8	3

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Ely Brook Tributary 1										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	6	6	2	6	3,300	597	541	1,990	892	62	39
Antimony	104	6	0									
Arsenic	190	6	2	0	2	.14						
Barium	3.8	6	6	6	6	31	16	3.2	23	23	14	10
Beryllium	5.09	6	1	0		.2						
Cadmium	1.1	6	4	1	4	1.90	*.35*	*.31*	*.98*			
Chromium	11	6	4	0	4	.5	.3	.1	.5			
Cobalt	3.06	6	6	1	6	32.7	5.59	5.42	16.5	8.44	.18	.06
Copper	11.8	6	6	5	6	2,460	420	407	1,240	629	14.9	10.3
Iron	1,000	3	2	0	3	133	52	41	171			
Lead	3.2	6	1	0	3	.05						
Manganese	80.3	6	6	1	6	224	39.3	37.1	114	60.3	2.2	.7
Mercury	.012	5	0									
Nickel	158	6	6	0	6	12.1	2.5	1.9	6.4	3.7	.7	.3
Selenium	5	6	2	0	3	.4						
Silver	.36	6	0									
Strontium	620	6	6	0	6	40	24	4	31	32	20	16
Thallium	18	6	0									
Uranium	1.87	2	2	0	2	.03						
Vanadium	19.1	6	2	0	5	.15	*.08*	*.02*	*.13*	.13	*.06*	*.05*
Zinc	106	6	6	1	6	171	38	27	92	63	12	4

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Ely Brook Tributary 2 from river meter 0 to 340										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	29	29	24	29	30,000	5,560	1,430	7,990	6,900	2,300	1,010
Antimony	104	36	7	0	27	3.10	*.18*	*.11*	*.37*	*.07*	*.01*	*<.01*
Arsenic	190	36	2	0	2	.09						
Barium	3.8	36	27	27	27	43	18	1.8	21	19	17	11
Beryllium	5.09	37	19	0	28	1.30	*.26*	*.05*	*.35*	*.40*	*.16*	*.07*
Cadmium	1.1	39	26	23	30	42.0	5.32	1.74	8.27	3.03	2.15	*1.23*
Chromium	11	39	15	4	30	57	5.0	2.4	9.1	*2.2*	*.3*	*.1*
Cobalt	3.06	39	30	24	30	1,000	127	44.6	202	66.1	42.0	19.6
Copper	11.8	39	37	36	37	24,000	2,920	917	4,460	1,800	1,170	63.0
Iron	1,000	19	16	9	19	197,000	21,600	11,700	41,900	14,000	565	22
Lead	3.2	39	23	0	30	2.20	*.41*	*.09*	*.56*	*.61*	*.21*	*.09*
Manganese	80.3	39	39	32	39	1,700	420	75.3	547	564	212	94.0
Mercury	.012	12	0									
Nickel	158	39	30	2	30	210	32	9.3	48	27	13	7.5
Selenium	5	39	14	0	29	4.0	*.6*	*.2*	*.9*	*.8*	*.3*	*.1*
Silver	.36	36	8	0	16	.04						
Strontium	620	27	27	0	27	100	48	4.60	56	63	40	30
Thallium	18	39	3	0	26	.1	*.03*	*.005*	*.04*	*.04*	*.02*	*.01*
Uranium	1.87	17	15	3	17	6.20	1.04	.47	1.85	.88	.20	.06
Vanadium	19.1	39	10	0	30	7.80	*.49*	*.28*	*.96*	*.21*	*.04*	*.01*
Zinc	106	39	37	26	37	2,800	440	110	625	390	240	53

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Ely Brook Tributary 2 above river meter 340										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	9	9	2	9	430	114	56	219	232	30	18
Antimony	104	15	4	0	9	1.10	*.48*	*.10*	*.66*	*.70*	*.36*	*.26*
Arsenic	190	15	2	0	9	1.00	*.24*	*.10*	*.42*	*.23*	*.13*	*.11*
Barium	3.8	15	9	9	9	30	17	1.9	20	18	17	13
Beryllium	5.09	15	0									
Cadmium	1.1	15	2	0	8	.08	*.01*	*.01*	*.03*	*.02*	*<.01*	*<.01*
Chromium	11	15	2	0	9	2.0	*.4*	*.2*	*.8*	*.5*	*.2*	*.1*
Cobalt	3.06	15	9	0	9	.66	.23	.08	.37	.42	.13	.04
Copper	11.8	15	9	0	9	11.0	2.3	1.1	4.4	2.3	1.0	.7
Iron	1000	8	8	0	8	560	297	63	415	415	316	113
Lead	3.2	15	6	0	9	.10	.07	.01	.08	.10	.06	*.04*
Manganese	80.3	15	9	6	9	1,300	395	161	695	767	201	15.1
Mercury	.012	1	0									
Nickel	158	15	7	0	9	2.7	.7	.3	1.2	.7	.6	*.1*
Selenium	5	15	1	0	5	.5						
Silver	.36	11	3	0	6	.04	*.02*	*.005*	*.03*	*.02*	*.01*	*.01*
Strontium	620	9	9	0	9	57	32	4	40	42	30	20
Thallium	18	15	0									
Uranium	1.87	8	4	0	5	.01	.01	.001	.01	.01	.01	<.01
Vanadium	19.1	15	6	0	9	.70	*.25*	*.06*	*.36*	*.32*	*.20*	*.12*
Zinc	106	15	12	0	12	44	18	5	27	37	11	2

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Ely Brook Tributary 3										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	23	23	23	23	30,000	19,300	1,710	22,300	26,000	22,000	9,900
Antimony	104	23	4	0	18	.45	*.03*	*.02*	*.08*	*.02*	*<.01*	*<.01*
Arsenic	190	23	0									
Barium	3.8	23	23	22	23	25	14	1.3	16	20	12	10
Beryllium	5.09	23	23	0	23	1.90	.88	.11	1.06	1.20	.80	.47
Cadmium	1.1	23	23	22	23	23.0	8.33	1.33	10.6	11.3	6.20	3.00
Chromium	11	23	22	9	23	21	9.7	1.0	11	12	9	6.3
Cobalt	3.06	23	23	23	23	490	231	29.0	281	360	220	94.0
Copper	11.8	23	23	22	23	19,000	7,200	1,150	9,150	12,000	7,000	2,600
Iron	1,000	17	17	16	17	100,000	26,300	7,580	39,500	32,400	15,000	4,500
Lead	3.2	23	22	1	23	5.00	.89	.22	1.27	1.10	.60	.27
Manganese	80.3	23	23	23	23	3,600	1,660	172	1,960	2,100	1,780	1,080
Mercury	.012	10	0									
Nickel	158	23	23	0	23	140	67	7.6	80	100	60	35
Selenium	5	23	14	1	23	5.0	1.2	.3	1.7	3.0	.5	.2
Silver	.36	23	16	0	21	.12	*.04*	*.01*	*.06*	*.07*	*.03*	*.01*
Strontium	620	23	23	0	23	180	93	9	108	130	100	60
Thallium	18	23	12	0	21	.16	*.07*	*.01*	*.08*	*.10*	*.06*	*.04*
Uranium	1.87	15	15	6	15	3.60	1.87	.28	2.36	2.90	1.60	1.20
Vanadium	19.1	23	9	0	23	5.80	.77	.37	1.41	*.30*	*.05*	*.01*
Zinc	106	23	23	23	23	2,700	1,080	135	1,310	1,460	850	590

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Ely Brook Tributary 4										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	5	5	5	5	>200,000	47,600	32,300	112,800	102,500	5,850	2,250
Antimony	104	6	2	0	6	.08	*.04*	*.01*	*.06*	*.06*	*.03*	*.02*
Arsenic	190	6	2	0	3	.42						
Barium	3.8	6	6	6	6	38	24	5.2	35	37	26	12
Beryllium	5.09	6	6	0	6	2.70	1.05	.48	2.01	2.48	.42	.19
Cadmium	1.1	6	6	6	6	25.0	9.48	4.61	18.8	23.5	2.85	1.80
Chromium	11	6	5	2	6	120	33	21	77	88	.6	.4
Cobalt	3.06	6	6	6	6	1,600	539	305	1,150	1,450	85.2	37.0
Copper	11.8	6	6	6	6	76,000	22,800	13,400	49,800	58,000	3,260	1,260
Iron	1000	3	2	2	3	17,000						
Lead	3.2	6	5	0	6	.29	.17	.04	.24	.22	.18	.08
Manganese	80.3	6	6	6	6	5,700	2,090	1,070	4,240	5,320	616	217
Mercury	.012	3	0									
Nickel	158	6	6	2	6	380	136	72.6	283	358	33.0	12.0
Selenium	5	6	4	2	6	6.4	2.3	1.2	4.7	5.9	*.7*	*.2*
Silver	.36	6	2	0	3	.07						
Strontium	620	6	6	0	6	180	106	29	164	180	110	30
Thallium	18	6	4	0	6	.20	.11	.03	.16	.18	*.08*	*.06*
Uranium	1.87	3	3	2	3	8.20						
Vanadium	19.1	6	1	0	2	.07						
Zinc	106	6	6	6	6	2,500	965	456	1,880	2,350	308	202

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Schoolhouse Brook from river meter 0 to 2,915										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	16	16	14	16	700	226	39	293	263	208	142
Antimony	104	15	5	0	14	1.70	*.16*	*.12*	*.37*	*.08*	*.02*	*<.01*
Arsenic	190	15	0									
Barium	3.8	15	15	15	15	325	42	20	78	25	18	15
Beryllium	5.09	15	0									
Cadmium	1.1	19	12	0	17	.25	*.09*	*.01*	*.12*	*.13*	*.08*	*.05*
Chromium	11	19	3	0	3	.21						
Cobalt	3.06	19	17	8	19	5.80	2.39	.34	2.98	3.40	2.30	1.40
Copper	11.8	19	18	16	19	85.0	32.1	4.9	40.6	41.0	26.2	20.4
Iron	1,000	12	7	0	12	120	39	11	58	62	*20*	*12*
Lead	3.2	19	5	0	15	.87	*.10*	*.06*	*.20*	*.10*	*.03*	*.01*
Manganese	80.3	19	19	0	19	35.9	17.2	2.2	20.9	23.0	16.6	13.6
Mercury	.012	8	1	1	2	.17						
Nickel	158	19	18	0	19	1.7	*1.0*	*1.0*	*1.1*	*1.3*	*1.0*	*.7*
Selenium	5	19	3	0	9	.5						
Silver	.36	19	1	0	8	.06						
Strontium	620	14	14	0	14	230	133	14	158	161	145	77
Thallium	18	19	0									
Uranium	1.87	11	11	0	11	.52	.23	.05	.32	.32	.24	.05
Vanadium	19.1	19	5	0	15	.30	*.11*	*.02*	*.14*	*.13*	*.09*	*.06*
Zinc	106	19	19	0	19	69	18	4	25	20	14	8

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Schoolhouse Brook from river meter 2,915 to 3,270										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	17	17	15	17	1,400	409	75	540	455	360	280
Antimony	104	16	6	0	11	.78	.11	.07	.23	.10	.02	.01
Arsenic	190	16	3	0								
Barium	3.8	16	16	16	16	289	41	17	71	28	*19*	*16*
Beryllium	5.09	16	0									
Cadmium	1.1	20	12	0	17	.46	*.16*	*.02*	*.20*	.21	*.13*	*.10*
Chromium	11	20	6	0	11	.54	*.23*	*.04*	*.30*	*.29*	*.18*	*.15*
Cobalt	3.06	20	20	16	20	11.0	4.56	.48	5.40	5.28	3.95	3.22
Copper	11.8	20	20	20	20	110	54.8	6.2	65.5	79.5	47.5	33.4
Iron	1,000	13	9	0	13	190	72	17	103	135	49	*19*
Lead	3.2	20	2	0	11	.07	*.04*	*.004*	*.04*	*.04*	*.03*	.02
Manganese	80.3	20	20	0	20	62.0	33.6	2.3	37.7	39.9	34.0	27.4
Mercury	.012	12	2	2	4	.14						
Nickel	158	20	19	0	20	2.3	*1.4*	*.1*	*1.6*	1.7	*1.4*	*1.2*
Selenium	5	20	4	0	11	.4	*.2*	*.03*	*.2*	.3	*.1*	*.1*
Silver	.36	20	1	0	8	.02						
Strontium	620	15	15	0	15	260	135	16	162	160	157	76
Thallium	18	20	0									
Uranium	1.87	9	9	0	9	.55	.23	.07	.36	.42	.14	.05
Vanadium	19.1	20	7	0	18	.20	.11	.01	.12	.13	*.10*	*.08*
Zinc	106	20	20	0	20	63	26	3	31	29	20	17

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Schoolhouse Brook above river meter 3,270										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	13	13	6	13	730	163	60	270	228	52	32
Antimony	104	12	4	0	9	.22	.06	.02	.10	.09	*.02*	*.01*
Arsenic	190	12	0									
Barium	3.8	12	12	12	12	110	33	8.4	48	28	23	18
Beryllium	5.09	12	0									
Cadmium	1.1	14	1	0	14	.02						
Chromium	11	14	3	0	5	.58						
Cobalt	3.06	14	4	0	14	1.90	*.17*	.14	*.42*	*.04*	*<.01*	*<.01*
Copper	11.8	14	6	0	14	1.1	*.5*	*.1*	*.7*	*.9*	*.4*	*.3*
Iron	1,000	9	0									
Lead	3.2	14	5	0	14	1.90	*.16*	*.13*	*.40*	*.05*	*.01*	*<.01*
Manganese	80.3	14	14	0	14	8.5	5.6	.3	6.2	6.0	5.5	5.0
Mercury	.012	4	0									
Nickel	158	14	6	0	13	.9	*.3*	*.1*	*.4*	*.5*	*.2*	*.1*
Selenium	5	14	0									
Silver	.36	14	0									
Strontium	620	11	11	0	11	230	134	19	168	170	130	82
Thallium	18	14	0									
Uranium	1.87	9	9	0	9	.64	.25	.08	.39	.44	.16	.07
Vanadium	19.1	14	5	0	12	.40	*.16*	*.03*	*.21*	*.20*	*.13*	.07
Zinc	106	14	13	0	14	49	13	4	20	24	*4*	*2*

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Ompompanoosuc River from river meter 8,350 to 20,000										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	20	17	13	20	379	*131*	*23*	*172*	*198*	*94*	62
Antimony	104	15	4	0	7	.28						
Arsenic	190	15	1	0	6	0.3						
Barium	3.8	15	15	15	15	374	112	38	180	337	24	19
Beryllium	5.09	15	1	0	15	1.2						
Cadmium	1.1	15	3	0	7	.03						
Chromium	11	15	4	0	15	3.4	*.7*	*.3*	*1.2*	*.6*	*.2*	*.1*
Cobalt	3.06	15	6	0	14	1.10	*.25*	*.07*	*.38*	*.31*	*.17*	*.07*
Copper	11.8	15	14	0	15	11.0	4.6	.9	6.2	8.5	3.0	*1.5*
Iron	1,000	9	3	0	9	42	*17*	*4*	*24*	25	*13*	*8*
Lead	3.2	15	4	0	14	2.60	*.53*	*.27*	*1.01*	*.57*	*.01*	*<.01*
Manganese	80.3	15	15	1	15	160	25.0	9.9	42.4	21.9	15.1	9.5
Mercury	.012	10	2	2	10	.16	*.06*	*.01*	*.09*	*.09*	*.05*	*.03*
Nickel	158	15	6	0	15	4.2	*.4*	*.3*	*.9*	*.3*	*.1*	*.1*
Selenium	5	15	1	0	15	3.6						
Silver	.36	15	2	2	12	.42	*.23*	*.02*	*.28*	*.27*	*.21*	*.16*
Strontium	620	7	7	0	7	230	118	26	168	190	99	60
Thallium	18	15	1	0	10	5.0						
Uranium	1.87	7	7	0	7	.64	.21	.08	.36	.32	.12	.05
Vanadium	19.1	15	3	0	7	.30						
Zinc	106	15	15	0	15	62	16	4	24	21	13	2

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Ompompanoosuc River from river meter 20,000 to 23,640										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean			Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
							Value (µg/L)	SE (µg/L)	95% UCL (µg/L)			
Aluminum	87	11	11	6	11	470	144	46	227	140	118	38
Antimony	104	10	6	0	10	3.00	*.34*	*.30*	*.88*	*.09*	*.04*	*.02*
Arsenic	190	10	1	0	4	.29						
Barium	3.8	10	10	10	10	46	25	2.8	30	28	24	19
Beryllium	5.09	10	0									
Cadmium	1.1	10	6	0	9	.10	.04	.01	.06	.07	.02	*.01*
Chromium	11	10	2	0	10	1.0	*.3*	*.1*	*.4*	*.3*	*.2*	*.1*
Cobalt	3.06	10	9	0	10	1.70	.60	.19	.94	1.15	.38	.09
Copper	11.8	10	10	4	10	12.0	10.2	2.4	14.5	17.3	9.3	3.2
Iron	1,000	10	4	0	10	48	*19*	*5*	*28*	30	*12*	*6*
Lead	3.2	10	3	0	9	.22	*.06*	*.03*	*.12*	.13	*.02*	*.01*
Manganese	80.3	10	10	0	10	14.0	10.0	.9	11.7	12.3	9.8	8.4
Mercury	.012	4	1	1	1	.2						
Nickel	158	10	8	0	10	.8	*.3*	*.1*	*.5*	.5	*.3*	*.2*
Selenium	5	10	0									
Silver	.36	10	2	0	7	.05	*.01*	.01	*.02*	*.01*	*<.01*	*<.01*
Strontium	620	10	10	0	10	190	128	14	155	158	139	80
Thallium	18	10	1	0	7	.09						
Uranium	1.87	9	9	0	9	.32	.18	.03	.25	.26	.24	.07
Vanadium	19.1	10	4	0	8	.44	*.15*	*.05*	*.24*	*.20*	*.10*	*.06*
Zinc	106	10	10	0	10	29	11	3	16	16	10	3

Appendix 5. Summary of select constituents in surface waters relative to ambient water-quality criteria (AWQC) for stream reaches in the Ely Mine study area, Vershire, VT, 2000 to 2007.—Continued

[Values in italics are estimated; chronic, average allowable concentration; >, greater than; <, less than; %, percent; SE, standard error; UCL, upper confidence level; Q3, 75th percentile; Q1, 25th percentile; mg/L, micrograms per liter]

Element	AWQC chronic (µg/L)	Ompompanoosuc River above river meter 23,640										
		Samples	Detects	Detects >AWQC	Samples used in analysis	Maximum (µg/L)	Mean Value (µg/L)	Mean SE (µg/L)	Mean 95% UCL (µg/L)	Q3 (µg/L)	Median (µg/L)	Q1 (µg/L)
Aluminum	87	12	12	5	12	390	118	35	182	162	72	33
Antimony	104	11	5	0	8	.09	.04	.01	.06	.07	*.04*	*.02*
Arsenic	190	11	3	0	8	.63	.21	.07	.34	.34	*.13*	*.07*
Barium	3.8	11	11	11	11	296	58	25	103	56	29	21
Beryllium	5.09	11	0									
Cadmium	1.1	11	0									
Chromium	11	11	2	0	11	1.1	*.25*	*.09*	*.42*	*.3*	*.14*	*.09*
Cobalt	3.06	11	1	0	1	.03						
Copper	11.8	11	3	0	10	.84	*.36*	*.06*	*.48*	*.45*	*.31*	*.23*
Iron	1,000	9	1	0	9	21						
Lead	3.2	11	2	0	10	.29	*.04*	*.03*	*.09*	*.03*	*<.01*	*<.01*
Manganese	80.3	11	11	0	11	26.0	9.1	2.1	12.8	12.0	6.4	4.4
Mercury	.012	3	0									
Nickel	158	11	3	0	10	.6	*.2*	*.06*	*.3*	*.2*	*.1*	*<.1*
Selenium	5	11	1	0	8	.2						
Silver	.36	11	4	0	8	.03	.01	.003	.02	.02	*.01*	*<.1*
Strontium	620	10	10	0	10	190	128	15	155	165	139	84
Thallium	18	11	0									
Uranium	1.87	9	9	0	9	.29	.16	.03	.22	.24	.16	.07
Vanadium	19.1	11	5	0	9	.41	.19	.04	.27	.30	.16	*.08*
Zinc	106	11	11	0	11	43	15	4	23	31	10	3

[a] Chronic toxicity standards for waters with pH 6.5–9.0 and for total recoverable concentrations (USEPA, 2006).

[b] From Suter, 1996.

[c] From VTDEC, 2006.

[d] Toxicity is hardness dependent and shown at hardness of 100 milligrams per liter.

Appendix 6. Constituents in surface waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Site No.	Previous sample ID	Split	Date	pH	S.C. (µS/cm)	Alkalinity (mg/L as $CaCO_3$)	Discharge (cfs)	Streamflow (L/s)	DOC (mg/L)	Ammonia (mg/L as N)	Nitrite (mg/L as N)	NO_2+NO_3 (mg/L as N)	Total N (mg/L)	Phosphorus (mg/L)
EB-1080M	06Ely01A FA	filtered	8/23/2006	7.2	87	41	0.04	0.99	1.9	<0.01	<0.002	<0.06	0.07	0.003 E[a]
EB-1080M	06Ely01A RA	raw	8/23/2006	7.2	87	—	—	—	—	—	—	—	—	—
EB-770M	06Ely02A FA	filtered	8/23/2006	6.3	149	11	0.04	1.13	0.8	0.005 E	<0.002	<0.06	0.04 E	0.002 E
EB-770M	06Ely02A RA	raw	8/23/2006	6.3	149	—	—	—	—	—	—	—	—	—
EB-600M	06Ely03A FA	filtered	8/23/2006	7.0	123	16	0.05	1.3	0.9	<0.01	<0.002	<0.06	0.05 E	<0.004
EB-600M	06Ely03A RA	raw	8/23/2006	7.0	123	—	—	—	—	—	—	—	—	—
EB-90M	06Ely04A FA	filtered	8/23/2006	3.2	447	—	0.22	6.23	1.6	0.023	<0.002	<0.06	0.07	0.004 E
EB-90M	06Ely04A RA	raw	8/23/2006	3.2	447	—	—	—	—	—	—	—	—	—
SB-3670M	06Ely05A FA	filtered	8/22/2006	8.2	212	99	2.9	82.4	1.2	<0.01	0.001	0.04 E	0.08	0.002 E
SB-3670M	06Ely05A RA	raw	8/22/2006	8.2	212	—	—	—	—	—	—	—	—	—
SB-3125M	06Ely19A FA	filtered	8/22/2006	7.8	215	89	3.4	96.9	1.3	<0.01	<0.002	0.04 E	0.11	0.005
SB-3125M	06Ely19A RA	raw	8/22/2006	7.8	215	—	—	—	—	—	—	—	—	—
SB-2400M	06Ely06A FA	filtered	8/22/2006	8.3	210	89	4.2	118	1.2	<0.01	<0.002	0.04 E	0.09	0.003 E
SB-2400M	06Ely06A RA	raw	8/22/2006	8.3	210	—	—	—	—	—	—	—	—	—
SB-1360M	06Ely07A FA	filtered	8/23/2006	7.9	203	86	4.7	132	1.5	<0.01	0.001 E	0.03 E	0.09	0.003 E
SB-1360M	06Ely07A RA	raw	8/23/2006	7.9	203	—	—	—	—	—	—	—	—	—
SB-140M	06Ely08A FA	filtered	8/21/2006	8.2	186	80	7.4	209	2	<0.01	0.001 E	<0.06	0.12	0.006
SB-140M	06Ely08A RA	raw	8/21/2006	8.2	186	—	—	—	—	—	—	—	—	—
OR-24050M	06Ely09A FA	filtered	8/21/2006	8.0	196	88	27	765	2.5	<0.01	0.001 E	0.07	0.21	0.007
OR-24050M	06Ely09A RA	raw	8/21/2006	8.0	196	—	—	—	—	—	—	—	—	—
OR-23630M	06Ely20A FA	filtered	8/21/2006	8.0	198	87	34	974	2.6	<0.01	0.001 E	0.07	0.2	0.006
OR-23630M	06Ely20A RA	raw	8/21/2006	8.0	198	—	—	—	—	—	—	—	—	—
OR-23200M	06Ely10A FA	filtered	8/21/2006	8.1	196	85	35	980	2.6	<0.01	0.001 E	0.06	0.2	0.005
OR-23200M	06Ely10A RA	raw	8/21/2006	8.1	196	—	—	—	—	—	—	—	—	—
EM-POND1	06ElyPond1 FA	filtered	09/19/06	7.0	51	19	—	—	3.5	0.008 E	<0.002	<0.06	0.46	0.036
EM-POND1	06ElyPond1 RA	raw	09/19/06	7.0	51	—	—	—	—	—	—	—	—	—
EM-POND2	06ElyPond2 FA	filtered	09/19/06	6.5	65	27	—	—	2.6	0.01	<0.002	<0.06	0.22	0.011
EM-POND2	06ElyPond2 RA	raw	09/19/06	6.5	65	—	—	—	—	—	—	—	—	—
EM-POND3	06ElyPond3 FA	filtered	09/19/06	6.7	70	31	—	—	2.6	0.031	<0.002	0.03 E	0.25	0.006
EM-POND3	06ElyPond3 RA	raw	09/19/06	6.7	70	—	—	—	—	—	—	—	—	—
EM-POND4	06ElyPond4 FA	filtered	09/19/06	6.7	78	30	—	—	2.2	0.01 E	<0.002	<0.06	0.19	0.007
EM-POND4	06ElyPond4 RA	raw	09/19/06	6.7	78	—	—	—	—	—	—	—	—	—
EM-POND5	06ElyPond5 FA	filtered	09/19/06	6.5	117	17	—	—	1.4	0.009 E	<0.002	<0.06	0.11	0.003 E
EM-POND5	06ElyPond5 RA	raw	09/19/06	6.5	117	—	—	—	—	—	—	—	—	—
EM-POND6	06ElyPond6 FA	filtered	09/19/06	4.7	206	—	—	—	1.1	0.015	<0.002	0.03 E	0.1	0.006
EM-POND6	06ElyPond6 RA	raw	09/19/06	4.7	206	—	—	—	—	—	—	—	—	—

Appendix 6. Constituents in surface waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Site No.	Previous sample ID	Orthophosphate (mg/L as P)	Job. No. ICP-AES & ICP-MS	Lab No. ICP-AES & ICP-MS	Field No. ICP-AES & ICP-MS	Ag (µg/L) ICP-AES	Al (µg/L) ICP-AES	As (µg/L) ICP-AES	B (µg/L) ICP-AES	Ba (µg/L) ICP-AES	Be (µg/L) ICP-AES
EB-1080M	06Ely01A FA	0.004 E	MRP-07541	C-289450	06Ely01A FA	<5	<20	<200	<5	21	<10
EB-1080M	06Ely01A RA	-	MRP-07541	C-289451	06Ely01A RA	<5	33	<200	<5	22	<10
EB-770M	06Ely02A FA	0.006	MRP-07541	C-289465	06Ely02A FA	<5	26	<200	<5	23	<10
EB-770M	06Ely02A RA	-	MRP-07541	C-289466	06Ely02A RA	<5	1,850	<200	<5	24	<10
EB-600M	06Ely03A FA	0.006	MRP-07541	C-289458	06Ely03A FA	<5	<20	<200	<5	20	<10
EB-600M	06Ely03A RA	-	MRP-07541	C-289457	06Ely03A RA	<5	634	<200	<5	20	<10
EB-90M	06Ely04A FA	0.011	MRP-07543	C-289545	06Ely04A FA	<5	4,790	<200	<5	21	<10
EB-90M	06Ely04A RA	-	MRP-07543	C-289546	06Ely04A RA	<5	4,840	<200	<5	21	<10
SB-3670M	06Ely05A FA	0.004 E	MRP-07543	C-289517	06Ely05A FA	<5	<20	<200	5.1	20	<10
SB-3670M	06Ely05A RA	-	MRP-07543	C-289518	06Ely05A RA	<5	37	<200	<5	20	<10
SB-3125M	06Ely19A FA	0.005 E	MRP-07543	C-289519	06Ely19A FA	<5	109	<200	<5	20	<10
SB-3125M	06Ely19A RA	-	MRP-07543	C-289520	06Ely19A RA	<5	329	<200	<5	20	<10
SB-2400M	06Ely06A FA	0.005 E	MRP-07541	C-289487	06Ely06A FA	<5	130	<200	<5	19	<10
SB-2400M	06Ely06A RA	-	MRP-07541	C-289488	06Ely06A RA	<5	232	<200	<5	20	<10
SB-1360M	06Ely07A FA	0.004 E	MRP-07541	C-289485	06Ely07A FA	<5	77	<200	<5	18	<10
SB-1360M	06Ely07A RA	-	MRP-07541	C-289486	06Ely07A RA	<5	163	<200	<5	19	<10
SB-140M	06Ely08A FA	0.004 E	MRP-07541	C-289475	06Ely08A FA	<5	108	<200	<5	16	<10
SB-140M	06Ely08A RA	-	MRP-07541	C-289476	06Ely08A RA	<5	235	<200	<5	17	<10
OR-24050M	06Ely09A FA	0.005 E	MRP-07541	C-289477	06Ely09A FA	<5	<20	<200	<5	21	<10
OR-24050M	06Ely09A RA	-	MRP-07541	C-289478	06Ely09A RA	<5	161	<200	<5	23	<10
OR-23630M	06Ely20A FA	0.005 E	MRP-07541	C-289483	06Ely20A FA	<5	<20	<200	<5	21	<10
OR-23630M	06Ely20A RA	-	MRP-07541	C-289484	06Ely20A RA	<5	120	<200	<5	23	<10
OR-23200M	06Ely10A FA	0.004 E	MRP-07541	C-289479	06Ely10A FA	<5	44	<200	<5	20	<10
OR-23200M	06Ely10A RA	-	MRP-07541	C-289480	06Ely10A RA	<5	130	<200	<5	21	<10
EM-POND1	06ElyPond1 FA	<0.006	MRP-07596	C-290528	06ElyPond1 FA	<5	<20	<200	<5	10	<10
EM-POND1	06ElyPond1 RA	-	MRP-07596	C-290529	06ElyPond1 RA	<5	413	<200	<5	13	<10
EM-POND2	06ElyPond2 FA	0.003 E	MRP-07596	C-290530	06ElyPond2 FA	<5	<20	<200	<5	14	<10
EM-POND2	06ElyPond2 RA	-	MRP-07596	C-290531	06ElyPond2 RA	<5	22	<200	<5	14	<10
EM-POND3	06ElyPond3 FA	<0.006	MRP-07596	C-290532	06ElyPond3 FA	5.9	<20	<200	<5	13	<10
EM-POND3	06ElyPond3 RA	-	MRP-07596	C-290533	06ElyPond3 RA	<5	20	<200	<5	13	<10
EM-POND4	06ElyPond4 FA	0.004 E	MRP-07596	C-290534	06ElyPond4 FA	<5	<20	<200	<5	19	<10
EM-POND4	06ElyPond4 RA	-	MRP-07596	C-290535	06ElyPond4 RA	<5	41	<200	<5	15	<10
EM-POND5	06ElyPond5 FA	0.004 E	MRP-07596	C-290537	06ElyPond5 FA	<5	<20	<200	<5	14	<10
EM-POND5	06ElyPond5 RA	-	MRP-07596	C-290538	06ElyPond5 RA	<5	531	<200	<5	15	<10
EM-POND6	06ElyPond6 FA	0.005 E	MRP-07596	C-290541	06ElyPond6 FA	<5	2,200	<200	<5	16	<10
EM-POND6	06ElyPond6 RA	-	MRP-07596	C-290542	06ElyPond6 RA	<5	3,490	<200	<5	16	<10

Appendix 6. Constituents in surface waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Site No.	Previous sample ID	Ca (mg/L) ICP-AES	Cd (µg/L) ICP-AES	Co (µg/L) ICP-AES	Cr (µg/L) ICP-AES	Cu (µg/L) ICP-AES	Fe (µg/L) ICP-AES	K (mg/L) ICP-AES	Li (µg/L) ICP-AES	Mg (mg/L) ICP-AES	Mn (µg/L) ICP-AES	Mo (µg/L) ICP-AES	Na (mg/L) ICP-AES	Ni (µg/L) ICP-AES	P (mg/L) ICP-AES
EB-1080M	06Ely01A FA	13.4	<5	<10	<10	<10	22	1.69	<5	1.18	136	<20	1.12	<10	<0.5
EB-1080M	06Ely01A RA	13.6	<5	<10	<10	<10	121	1.74	<5	1.21	182	<20	1.13	<10	<0.5
EB-770M	06Ely02A FA	17.2	<5	37	<10	981	<20	2.43	7.6	3.2	247	<20	1.64	14	<0.5
EB-770M	06Ely02A RA	17.7	<5	38	<10	1,240	82	2.5	7.8	3.31	255	<20	1.69	15	<0.5
EB-600M	06Ely03A FA	14.9	<5	15	<10	240	<20	2.17	<5	2.43	101	<20	1.44	<10	<0.5
EB-600M	06Ely03A RA	15.1	<5	16	<10	447	52	2.19	<5	2.47	104	<20	1.46	<10	<0.5
EB-90M	06Ely04A FA	21.1	<5	77	<10	1,780	6,370	3.42	16	5.54	599	<20	2.3	21	<0.5
EB-90M	06Ely04A RA	21.1	<5	74	<10	1,800	6,510	3.44	16	5.58	601	<20	2.31	21	<0.5
SB-3670M	06Ely05A FA	35.7	<5	<10	<10	<10	<20	2.26	<5	1.71	<10	<20	3.89	<10	<0.5
SB-3670M	06Ely05A RA	36.6	<5	<10	<10	<10	42	2.34	<5	1.75	<10	<20	3.96	<10	<0.5
SB-3125M	06Ely19A FA	35.1	<5	<10	<10	44	49	2.34	<5	1.99	44	<20	4.16	<10	<0.5
SB-3125M	06Ely19A RA	35.5	<5	<10	<10	118	382	2.39	<5	2.03	48	<20	4.25	<10	<0.5
SB-2400M	06Ely06A FA	35.8	<5	<10	<10	23	<20	2.42	<5	2.03	32	<20	4.62	<10	<0.5
SB-2400M	06Ely06A RA	36.4	<5	<10	<10	69	197	2.46	<5	2.07	35	<20	4.67	<10	<0.5
SB-1360M	06Ely07A FA	33.8	<5	<10	<10	20	13	2.29	<5	1.95	19	<20	4.27	<10	<0.5
SB-1360M	06Ely07A RA	34.3	<5	<10	<10	54	193	2.31	<5	1.98	21	<20	4.33	<10	<0.5
SB-140M	06Ely08A FA	30.7	<5	<10	<10	20	20	2.2	<5	1.82	15	<20	3.77	<10	<0.5
SB-140M	06Ely08A RA	31.8	<5	<10	<10	55	262	2.27	<5	1.88	21	<20	3.88	<10	<0.5
OR-24050M	06Ely09A FA	32	<5	<10	<10	<10	<20	2.16	<5	1.46	<10	<20	5.22	<10	<0.5
OR-24050M	06Ely09A RA	33.1	<5	<10	<10	<10	179	2.22	<5	1.58	29	<20	5.37	<10	<0.5
OR-23630M	06Ely20A FA	32.9	<5	<10	<10	<10	<20	2.23	<5	1.55	<10	<20	5.45	<10	<0.5
OR-23630M	06Ely20A RA	32.9	<5	<10	<10	<10	123	2.26	<5	1.59	30	<20	5.46	<10	<0.5
OR-23200M	06Ely10A FA	32.6	<5	<10	<10	<10	<20	2.24	<5	1.61	<10	<20	5.15	<10	<0.5
OR-23200M	06Ely10A RA	32.7	<5	<10	<10	14	146	2.27	<5	1.64	20	<20	5.13	<10	<0.5
EM-POND1	06ElyPond1 FA	5.77	<5	<10	<10	<10	66	1.67	<5	1.07	<10	<20	1.2	<10	<0.5
EM-POND1	06ElyPond1 RA	5.98	<5	<10	<10	<10	537	1.7	<5	1.25	<10	<20	1.22	<10	<0.5
EM-POND2	06ElyPond2 FA	7.67	<5	<10	<10	<10	353	1.78	<5	1.11	201	<20	1.34	<10	<0.5
EM-POND2	06ElyPond2 RA	7.99	<5	<10	<10	<10	1,190	1.83	<5	1.16	220	<20	1.37	<10	<0.5
EM-POND3	06ElyPond3 FA	8.72	<5	<10	<10	<10	253	1.75	<5	1.17	444	<20	1.3	<10	<0.5
EM-POND3	06ElyPond3 RA	8.98	<5	<10	<10	<10	1010	1.78	<5	1.21	464	<20	1.34	<10	<0.5
EM-POND4	06ElyPond4 FA	9.7	<5	<10	<10	13	105	1.86	<5	1.37	212	<20	1.32	<10	<0.5
EM-POND4	06ElyPond4 RA	9.74	<5	<10	<10	17	423	1.86	<5	1.38	240	<20	1.31	<10	<0.5
EM-POND5	06ElyPond5 FA	13	<5	24	<10	494	<20	2.13	<5	2.44	425	<20	1.41	<10	<0.5
EM-POND5	06ElyPond5 RA	13.4	<5	24	<10	595	130	2.17	<5	2.49	435	<20	1.41	<10	<0.5
EM-POND6	06ElyPond6 FA	18.6	<5	62	<10	1,800	565	2.54	9.3	4.17	709	<20	1.6	20	<0.5
EM-POND6	06ElyPond6 RA	19.2	<5	64	<10	1,890	701	2.61	9.6	4.3	729	<20	1.64	21	<0.5

Appendix 6. Constituents in surface waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Site No.	Previous sample ID	Pb (µg/L) ICP-AES	Sb (µg/L) ICP-AES	SiO_2 (mg/L) ICP-AES	SO_4 (mg/L) ICP-AES	Sr (µg/L) ICP-AES	Ti (µg/L) ICP-AES	V (µg/L) ICP-AES	Zn (µg/L) ICP-AES	Ag (µg/L) ICP-MS	Al (µg/L) ICP-MS	As (µg/L) ICP-MS	Ba (µg/L) ICP-MS	Be (µg/L) ICP-MS	Bi (µg/L) ICP-MS	Ca (mg/L) ICP-MS
EB-1080M	06Ely01A FA	<50	<50	9.1	3.9	50	<50	<10	<20	<3	3.4	<1	18.4	<0.05	<0.2	11.3
EB-1080M	06Ely01A RA	<50	<50	9.2	4	51	<50	<10	<20	<3	33.9	<1	20.3	<0.05	<0.2	12
EB-770M	06Ely02A FA	<50	<50	17.2	52.5	64	<50	<10	105	<3	25.1	<1	19.9	0.06	<0.2	13.9
EB-770M	06Ely02A RA	<50	<50	18.3	54.5	66	<50	<10	109	<3	1,320	<1	20.1	0.1	<0.2	14.5
EB-600M	06Ely03A FA	<50	<50	13.7	37.6	54	<50	<10	49	<3	20.7	<1	17	<0.05	<0.2	12.2
EB-600M	06Ely03A RA	<50	<50	14.2	38.2	54	<50	<10	52	<3	484	<1	17.4	0.05	<0.2	12.1
EB-90M	06Ely04A FA	<50	<50	33.1	140	65	<50	<10	357	<3	4,190	<1	19	0.3	<0.2	18.2
EB-90M	06Ely04A RA	<50	<50	33.3	140	65	<50	<10	354	<3	3,890	<1	18.9	0.3	<0.2	17.8
SB-3670M	06Ely05A FA	<50	<50	7.3	7.7	181	<50	<10	<20	<3	12.8	<1	20.5	<0.05	<0.2	36
SB-3670M	06Ely05A RA	<50	<50	7.5	8	185	<50	<10	<20	<3	33.3	<1	20.4	<0.05	<0.2	36.8
SB-3125M	06Ely19A FA	<50	<50	8.9	17	174	<50	<10	<20	<3	124	<1	19.8	<0.05	<0.2	36
SB-3125M	06Ely19A RA	<50	<50	9.3	17.3	177	<50	<10	23	<3	364	<1	20.6	<0.05	<0.2	36.7
SB-2400M	06Ely06A FA	<50	<50	9.1	16.6	181	<50	<10	<20	<3	128	<1	18.5	<0.05	<0.2	34.6
SB-2400M	06Ely06A RA	<50	<50	9.3	16.9	184	<50	<10	<20	<3	234	<1	19.5	<0.05	<0.2	35.2
SB-1360M	06Ely07A FA	<50	<50	8.6	14.1	172	<50	<10	5.6	<3	84.4	<1	18.4	<0.05	<0.2	33.5
SB-1360M	06Ely07A RA	<50	<50	8.9	14.3	175	<50	<10	<20	<3	170	<1	18.5	<0.05	<0.2	33.6
SB-140M	06Ely08A FA	<50	<50	8.5	13	158	<50	<10	<20	<3	93.5	<1	14.8	<0.05	<0.2	27.7
SB-140M	06Ely08A RA	<50	<50	9	13.2	163	<50	<10	<20	<3	215	<1	16.6	<0.05	<0.2	29.7
OR-24050M	06Ely09A FA	<50	<50	7.2	7	156	<50	<10	<20	<3	13.4	<1	19.9	<0.05	<0.2	30.3
OR-24050M	06Ely09A RA	<50	<50	7.8	7.3	161	<50	<10	<20	<3	160	<1	22.1	<0.05	<0.2	31.5
OR-23630M	06Ely20A FA	<50	<50	7.6	7.8	161	<50	<10	<20	<3	23.3	<1	20.2	<0.05	<0.2	31.4
OR-23630M	06Ely20A RA	<50	<50	7.8	7.8	161	<50	<10	<20	<3	118	<1	22.6	<0.05	<0.2	32.8
OR-23200M	06Ely10A FA	<50	<50	7.8	8.9	161	<50	<10	<20	<3	44.6	<1	19.1	<0.05	<0.2	30.4
OR-23200M	06Ely10A RA	<50	<50	8	9	161	<50	<10	<20	<3	127	<1	19.9	<0.05	<0.2	31.5
EM-POND1	06ElyPond1 FA	<50	<50	2.2	6.2	24	<50	<10	<20	<3	15.8	<1	9.61	<0.05	<0.2	5.47
EM-POND1	06ElyPond1 RA	<50	<50	3.3	6.3	25	<50	<10	<20	<3	388	<1	12.2	<0.05	<0.2	5.76
EM-POND2	06ElyPond2 FA	<50	<50	4.6	4.9	30	<50	<10	<20	<3	6.5	<1	13.5	<0.05	<0.2	7.74
EM-POND2	06ElyPond2 RA	<50	<50	4.9	5.1	32	<50	<10	<20	<3	34.4	<1	14.1	<0.05	<0.2	8.4
EM-POND3	06ElyPond3 FA	<50	<50	5.1	4.5	35	<50	<10	<20	<3	6.2	<1	12.5	<0.05	<0.2	9.06
EM-POND3	06ElyPond3 RA	<50	<50	5.3	4.7	36	<50	<10	<20	<3	21.2	<1	13	<0.05	<0.2	9.36
EM-POND4	06ElyPond4 FA	<50	<50	5.5	8.3	39	<50	<10	<20	<3	5.5	<1	18.6	<0.05	<0.2	9.88
EM-POND4	06ElyPond4 RA	<50	<50	5.5	8.4	39	<50	<10	<20	<3	41.2	<1	14.6	<0.05	<0.2	9.92
EM-POND5	06ElyPond5 FA	<50	<50	9.2	34.1	44	<50	<10	147	<3	10.1	<1	13.7	<0.05	<0.2	11.8
EM-POND5	06ElyPond5 RA	<50	<50	9.5	34.7	45	<50	<10	150	<3	427	<1	13.5	0.06	<0.2	11.6
EM-POND6	06ElyPond6 FA	<50	<50	14.8	82.8	54	<50	<10	367	<3	1,410	<1	13.2	0.2	<0.2	13.9
EM-POND6	06ElyPond6 RA	<50	<50	15.6	86.5	56	<50	<10	378	<3	2,040	<1	12.6	0.2	<0.2	13.6

Appendix 6. Constituents in surface waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Site No.	Previous sample ID	Cd (µg/L) ICP-MS	Ce (µg/L) ICP-MS	Co (µg/L) ICP-MS	Cr (µg/L) ICP-MS	Cs (µg/L) ICP-MS	Cu (µg/L) ICP-MS	Dy (µg/L) ICP-MS	Er (µg/L) ICP-MS	Eu (µg/L) ICP-MS	Fe (µg/L) ICP-MS	Ga (µg/L) ICP-MS	Gd (µg/L) ICP-MS	Ge (µg/L) ICP-MS	Ho (µg/L) ICP-MS	K (mg/L) ICP-MS	La (µg/L) ICP-MS
EB-1080M	06Ely01A FA	<0.02	0.02	0.08	<1	0.02	1.3	0.006	<0.005	<0.005	<50	<0.05	0.007	<0.05	<0.005	1.42	0.03
EB-1080M	06Ely01A RA	<0.02	0.12	0.16	<1	0.04	1.7	0.01	0.007	0.005	86	<0.05	0.02	<0.05	<0.005	1.52	0.08
EB-770M	06Ely02A FA	0.95	8.8	31.1	<1	0.06	837	0.43	0.21	0.13	<50	0.06	0.71	<0.05	0.072	1.98	4.88
EB-770M	06Ely02A RA	0.94	11.9	32.2	<1	0.07	1,040	0.94	0.43	0.26	54	0.1	1.35	<0.05	0.15	2.04	5.79
EB-600M	06Ely03A FA	0.48	1.21	12.5	<1	0.05	211	0.04	0.02	0.02	<50	<0.05	0.08	<0.05	0.008	1.79	0.86
EB-600M	06Ely03A RA	0.51	3.82	12.9	<1	0.05	385	0.33	0.15	0.09	<50	<0.05	0.44	<0.05	0.05	1.76	1.93
EB-90M	06Ely04A FA	1.99	22.4	63	2.1	1.29	1,560	1.68	0.71	0.47	5,920	0.2	2.41	<0.05	0.29	3.04	10.8
EB-90M	06Ely04A RA	1.93	23.4	64.4	2.2	1.26	1,560	1.74	0.75	0.49	5,950	0.2	2.53	0.05	0.29	2.95	11.3
SB-3670M	06Ely05A FA	<0.02	<0.01	<0.02	<1	0.06	<0.5	<0.005	<0.005	<0.005	<50	<0.05	<0.005	<0.05	<0.005	2.45	0.01
SB-3670M	06Ely05A RA	<0.02	0.06	<0.02	<1	0.07	<0.5	<0.005	<0.005	<0.005	<50	<0.05	0.006	<0.05	<0.005	2.51	0.04
SB-3125M	06Ely19A FA	0.12	0.21	4.31	<1	0.15	42.8	0.02	0.008	0.007	<50	<0.05	0.02	<0.05	<0.005	2.58	0.11
SB-3125M	06Ely19A RA	0.15	1.36	4.5	<1	0.15	118	0.11	0.05	0.03	368	<0.05	0.15	<0.05	0.02	2.6	0.65
SB-2400M	06Ely06A FA	0.08	0.04	2.82	<1	0.13	25	0.006	<0.005	<0.005	<50	<0.05	0.005	<0.05	<0.005	2.5	0.03
SB-2400M	06Ely06A RA	0.11	0.72	3.16	<1	0.14	68.4	0.051	0.03	0.02	179	<0.05	0.073	<0.05	0.009	2.56	0.36
SB-1360M	06Ely07A FA	0.07	0.07	1.94	<1	0.1	21.6	0.005	<0.005	<0.005	<50	<0.05	0.009	<0.05	<0.005	2.39	0.04
SB-1360M	06Ely07A RA	0.09	0.64	2.09	<1	0.11	55.2	0.052	0.02	0.02	175	<0.05	0.076	<0.05	0.008	2.44	0.32
SB-140M	06Ely08A FA	0.05	0.09	1.1	<1	0.08	20.4	0.009	<0.005	<0.005	<50	<0.05	0.01	<0.05	<0.005	2	0.05
SB-140M	06Ely08A RA	0.07	0.79	1.47	<1	0.12	55	0.066	0.03	0.02	236	<0.05	0.094	<0.05	0.009	2.18	0.4
OR-24050M	06Ely09A FA	<0.02	0.02	<0.02	<1	0.08	0.84	0.006	<0.005	<0.005	<50	<0.05	0.008	<0.05	<0.005	2.16	0.03
OR-24050M	06Ely09A RA	<0.02	0.46	0.11	<1	0.12	0.6	0.03	0.02	0.01	162	0.05	0.04	<0.05	0.005	2.24	0.25
OR-23630M	06Ely20A FA	0.02	0.04	0.11	<1	0.08	3.3	0.008	<0.005	<0.005	<50	<0.05	0.007	<0.05	<0.005	2.3	0.03
OR-23630M	06Ely20A RA	<0.02	0.31	0.18	<1	0.11	5.9	0.03	0.01	0.009	113	<0.05	0.03	<0.05	0.005	2.4	0.17
OR-23200M	06Ely10A FA	0.1	0.08	0.31	<1	0.08	8.9	0.008	<0.005	<0.005	<50	<0.05	0.01	<0.05	<0.005	2.24	0.05
OR-23200M	06Ely10A RA	0.02	0.38	0.42	<1	0.1	15	0.03	0.02	0.01	126	<0.05	0.05	<0.05	0.006	2.29	0.21
EM-POND1	06ElyPond1 FA	<0.02	0.02	0.03	<1	0.05	1.1	<0.005	<0.005	<0.005	<50	<0.05	0.006	<0.05	<0.005	1.61	0.02
EM-POND1	06ElyPond1 RA	0.03	0.6	0.36	1.2	0.15	3.1	0.093	0.04	0.03	522	0.2	0.14	<0.05	0.02	1.72	0.49
EM-POND2	06ElyPond2 FA	<0.02	0.06	0.13	<1	0.04	2.9	0.008	0.006	<0.005	324	<0.05	0.01	<0.05	<0.005	1.74	0.03
EM-POND2	06ElyPond2 RA	<0.02	0.16	0.18	<1	0.05	1.3	0.02	0.01	0.008	1240	<0.05	0.03	<0.05	<0.005	1.88	0.09
EM-POND3	06ElyPond3 FA	<0.02	0.05	0.23	<1	0.05	1.7	0.009	0.005	0.005	243	<0.05	0.008	<0.05	<0.005	1.78	0.02
EM-POND3	06ElyPond3 RA	<0.02	0.13	0.26	<1	0.05	1.4	0.01	0.009	0.005	1020	<0.05	0.02	<0.05	<0.005	1.83	0.06
EM-POND4	06ElyPond4 FA	0.08	0.07	0.41	<1	0.05	13.4	0.009	0.005	0.005	84	<0.05	0.01	<0.05	<0.005	1.87	0.06
EM-POND4	06ElyPond4 RA	0.07	0.24	0.56	<1	0.05	19.3	0.02	0.01	0.007	412	<0.05	0.04	<0.05	<0.005	1.92	0.15
EM-POND5	06ElyPond5 FA	1.02	2.94	20.4	<1	0.13	444	0.14	0.071	0.05	<50	<0.05	0.25	<0.05	0.03	1.96	2.06
EM-POND5	06ElyPond5 RA	1.04	4.22	20.2	<1	0.13	518	0.32	0.14	0.089	87	0.05	0.47	<0.05	0.053	1.9	2.67
EM-POND6	06ElyPond6 FA	2.28	18.3	46.3	<1	0.23	1,380	1.54	0.66	0.4	434	0.2	2.24	<0.05	0.25	1.83	10.5
EM-POND6	06ElyPond6 RA	2.28	19.8	46.4	<1	0.23	1,440	1.61	0.71	0.44	528	0.2	2.37	0.05	0.27	1.82	11.1

Appendix 6. Constituents in surface waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Site No.	Previous sample ID	Li (µg/L) ICP-MS	Lu (µg/L) ICP-MS	Mg (mg/L) ICP-MS	Mn (µg/L) ICP-MS	Mo (µg/L) ICP-MS	Na (mg/L) ICP-MS	Nb (µg/L) ICP-MS	Nd (µg/L) ICP-MS	Ni (µg/L) ICP-MS	P (mg/L) ICP-MS	Pb (µg/L) ICP-MS	Pr (µg/L) ICP-MS	Rb (µg/L) ICP-MS	Sb (µg/L) ICP-MS
EB-1080M	06Ely01A FA	0.2	<0.1	0.95	124	<2	0.93	<0.2	0.03	0.5	<0.01	<0.05	<0.01	3.3	<0.3
EB-1080M	06Ely01A RA	<0.1	<0.1	1.02	169	<2	0.98	<0.2	0.08	0.5	<0.01	<0.05	0.02	3.61	<0.3
EB-770M	06Ely02A FA	6.7	<0.1	2.54	217	<2	1.28	<0.2	4.17	12.1	<0.01	0.1	1.06	7.87	<0.3
EB-770M	06Ely02A RA	7.3	<0.1	2.6	224	<2	1.31	<0.2	6.87	12.2	<0.01	0.2	1.65	7.94	0.34
EB-600M	06Ely03A FA	3.8	<0.1	1.91	92.8	<2	1.14	0.6	0.53	6.4	<0.01	0.06	0.15	6.03	<0.3
EB-600M	06Ely03A RA	3.2	<0.1	1.91	93.9	<2	1.15	<0.2	2.29	6.2	<0.01	0.07	0.54	6	<0.3
EB-90M	06Ely04A FA	15.2	<0.1	4.69	521	<2	2	<0.2	12.2	19.5	<0.01	0.95	3.05	15	<0.3
EB-90M	06Ely04A RA	15.1	<0.1	4.41	528	<2	1.87	<0.2	12.8	19.5	<0.01	0.87	3.2	15.6	<0.3
SB-3670M	06Ely05A FA	2.8	<0.1	1.92	5.6	<2	4.4	<0.2	<0.01	<0.4	<0.01	0.05	<0.01	4.79	<0.3
SB-3670M	06Ely05A RA	3.1	<0.1	2.02	8.8	<2	4.5	<0.2	0.04	<0.4	<0.01	<0.05	0.01	4.91	<0.3
SB-3125M	06Ely19A FA	3.4	<0.1	2.35	43.8	<2	4.94	0.67	0.13	1.5	<0.01	0.07	0.03	5.34	0.78
SB-3125M	06Ely19A RA	4.2	<0.1	2.34	48	<2	4.9	0.29	0.76	1.7	<0.01	0.08	0.18	5.41	<0.3
SB-2400M	06Ely06A FA	3.2	<0.1	2.17	31.5	<2	4.94	<0.2	0.02	1.2	<0.01	<0.05	<0.01	5.37	<0.3
SB-2400M	06Ely06A RA	3.3	<0.1	2.21	34.2	<2	5.02	<0.2	0.4	1.1	<0.01	0.07	0.1	5.44	<0.3
SB-1360M	06Ely07A FA	2.7	<0.1	2.09	19.1	<2	4.56	<0.2	0.04	1.1	<0.01	<0.05	0.01	5.04	<0.3
SB-1360M	06Ely07A RA	3.3	<0.1	2.15	20.9	<2	4.67	<0.2	0.36	0.9	<0.01	0.06	0.08	5.18	<0.3
SB-140M	06Ely08A FA	1.4	<0.1	1.61	13.6	<2	3.41	<0.2	0.06	1	<0.01	0.1	0.01	4.58	<0.3
SB-140M	06Ely08A RA	2.5	<0.1	1.81	20.3	<2	3.68	0.67	0.47	0.8	<0.01	0.1	0.1	5	0.67
OR-24050M	06Ely09A FA	1.9	<0.1	1.46	4.7	<2	5.22	0.28	0.03	<0.4	<0.01	0.08	<0.01	5.22	<0.3
OR-24050M	06Ely09A RA	2.8	<0.1	1.56	28.2	<2	5.38	<0.2	0.24	0.5	<0.01	0.2	0.06	5.53	<0.3
OR-23630M	06Ely20A FA	2.6	<0.1	1.61	7.1	<2	5.61	<0.2	0.03	<0.4	<0.01	0.06	<0.01	5.23	<0.3
OR-23630M	06Ely20A RA	2.8	<0.1	1.75	30.2	<2	5.98	<0.2	0.15	0.4	<0.01	0.1	0.04	5.48	0.76
OR-23200M	06Ely10A FA	2.2	<0.1	1.58	8.9	<2	5.26	<0.2	0.05	0.5	<0.01	0.2	0.01	5.05	<0.3
OR-23200M	06Ely10A RA	2.6	<0.1	1.67	19.3	<2	5.27	<0.2	0.22	0.5	<0.01	0.1	0.06	5.25	<0.3
EM-POND1	06ElyPond1 FA	0.2	<0.1	0.92	2.7	<2	1.08	<0.2	0.02	<0.4	<0.01	0.09	<0.01	3.42	<0.3
EM-POND1	06ElyPond1 RA	1.2	<0.1	1.1	7.5	<2	1.11	<0.2	0.66	1	0.02	0.3	0.15	4.13	<0.3
EM-POND2	06ElyPond2 FA	0.2	<0.1	0.98	201	<2	1.25	<0.2	0.05	0.4	<0.01	0.08	<0.01	3.61	<0.3
EM-POND2	06ElyPond2 RA	0.1	<0.1	1.07	226	<2	1.38	<0.2	0.12	0.4	0.01	0.09	0.03	3.83	<0.3
EM-POND3	06ElyPond3 FA	0.2	<0.1	1.1	435	<2	1.31	0.38	0.04	0.6	<0.01	0.1	<0.01	3.73	0.62
EM-POND3	06ElyPond3 RA	<0.1	<0.1	1.14	454	<2	1.34	<0.2	0.09	<0.4	0.01	0.07	0.02	3.85	<0.3
EM-POND4	06ElyPond4 FA	0.3	<0.1	1.25	212	<2	1.29	<0.2	0.06	1.3	<0.01	0.1	0.01	4.08	<0.3
EM-POND4	06ElyPond4 RA	0.3	<0.1	1.3	241	<2	1.33	<0.2	0.16	0.9	0.01	0.09	0.04	4.2	<0.3
EM-POND5	06ElyPond5 FA	2.2	<0.1	1.99	386	<2	1.24	<0.2	1.61	7.7	<0.01	<0.05	0.42	5.75	<0.3
EM-POND5	06ElyPond5 RA	2.3	<0.1	1.88	387	<2	1.14	<0.2	2.65	7.5	<0.01	<0.05	0.64	5.76	<0.3
EM-POND6	06ElyPond6 FA	5.6	<0.1	2.55	564	<2	1.02	0.3	11.9	16.7	<0.01	0.4	2.9	7.78	0.52
EM-POND6	06ElyPond6 RA	5.3	<0.1	2.37	579	<2	0.96	<0.2	12.6	16.7	<0.01	0.4	3.11	7.95	<0.3

Appendix 6. Constituents in surface waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Site No.	Previous sample ID	Sc (µg/L) ICP-MS	Se (µg/L) ICP-MS	SiO_2 (mg/L) ICP-MS	Sm (µg/L) ICP-MS	Sr (µg/L) ICP-MS	Ta (µg/L) ICP-MS	Tb (µg/L) ICP-MS	Th (µg/L) ICP-MS	Ti (µg/L) ICP-MS	Tl (µg/L) ICP-MS	Tm (µg/L) ICP-MS	U (µg/L) ICP-MS	V (µg/L) ICP-MS	W (µg/L) ICP-MS	Y (µg/L) ICP-MS
EB-1080M	06Ely01A FA	<0.6	<1	6.8	<0.01	47.6	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	<0.1	<0.5	<0.5	0.03
EB-1080M	06Ely01A RA	0.6	<1	7	0.02	50.9	<0.02	<0.005	<0.2	1.9	<0.1	<0.005	<0.1	<0.5	<0.5	0.07
EB-770M	06Ely02A FA	1.1	<1	12.6	0.66	62.3	<0.02	0.079	<0.2	<0.5	<0.1	0.02	<0.1	<0.5	<0.5	2.3
EB-770M	06Ely02A RA	1.4	<1	12.2	1.35	61.6	0.04	0.17	<0.2	3.3	<0.1	0.05	0.29	<0.5	<0.5	3.62
EB-600M	06Ely03A FA	0.9	<1	9.9	0.07	52.6	0.09	0.009	<0.2	<0.5	<0.1	<0.005	<0.1	<0.5	0.58	0.27
EB-600M	06Ely03A RA	0.9	<1	10.1	0.45	51.9	<0.02	0.054	<0.2	1.7	<0.1	0.02	0.11	<0.5	<0.5	1.26
EB-90M	06Ely04A FA	2.9	<1	26.7	2.36	64	<0.02	0.33	<0.2	2.1	<0.1	0.081	0.42	<0.5	<0.5	5.99
EB-90M	06Ely04A RA	2.8	<1	24.9	2.51	65.7	<0.02	0.34	<0.2	2.6	<0.1	0.085	0.43	<0.5	<0.5	6.14
SB-3670M	06Ely05A FA	0.7	<1	6.8	<0.01	166	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.32	<0.5	<0.5	0.02
SB-3670M	06Ely05A RA	0.7	<1	7.2	0.01	166	<0.02	<0.005	<0.2	1.3	<0.1	<0.005	0.33	<0.5	<0.5	0.03
SB-3125M	06Ely19A FA	0.8	<1	8.8	0.02	157	0.1	<0.005	<0.2	<0.5	<0.1	<0.005	0.31	<0.5	0.61	0.08
SB-3125M	06Ely19A RA	0.9	<1	9.1	0.15	157	0.04	0.02	<0.2	1.4	<0.1	<0.005	0.32	<0.5	<0.5	0.43
SB-2400M	06Ely06A FA	0.8	<1	8.1	<0.01	158	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.3	<0.5	<0.5	0.03
SB-2400M	06Ely06A RA	0.9	<1	8.4	0.08	158	<0.02	0.01	<0.2	1	<0.1	<0.005	0.31	<0.5	<0.5	0.23
SB-1360M	06Ely07A FA	0.8	<1	7.7	0.01	152	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.27	<0.5	<0.5	0.04
SB-1360M	06Ely07A RA	0.8	<1	8.1	0.07	155	<0.02	0.01	<0.2	0.9	<0.1	<0.005	0.28	<0.5	<0.5	0.22
SB-140M	06Ely08A FA	0.7	<1	6.5	<0.01	134	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.24	<0.5	<0.5	0.04
SB-140M	06Ely08A RA	0.8	<1	7.3	0.09	144	0.1	0.01	<0.2	3.4	<0.1	<0.005	0.28	<0.5	0.56	0.26
OR-24050M	06Ely09A FA	0.6	<1	6	<0.01	138	0.05	<0.005	<0.2	<0.5	<0.1	<0.005	0.24	<0.5	<0.5	0.03
OR-24050M	06Ely09A RA	0.7	<1	6.6	0.04	141	<0.02	0.006	<0.2	7.2	<0.1	<0.005	0.26	0.5	<0.5	0.18
OR-23630M	06Ely20A FA	0.7	<1	6.5	<0.01	139	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.24	<0.5	<0.5	0.03
OR-23630M	06Ely20A RA	0.8	<1	7.2	0.03	142	0.06	<0.005	<0.2	4.3	<0.1	<0.005	0.25	<0.5	<0.5	0.13
OR-23200M	06Ely10A FA	0.7	<1	6.5	<0.01	139	<0.02	<0.005	<0.2	0.6	<0.1	<0.005	0.24	<0.5	<0.5	0.04
OR-23200M	06Ely10A RA	0.7	<1	6.9	0.04	141	<0.02	0.006	<0.2	3.8	<0.1	<0.005	0.25	<0.5	<0.5	0.15
EM-POND1	06ElyPond1 FA	<0.6	<1	1.8	<0.01	20.5	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	<0.1	<0.5	<0.5	0.02
EM-POND1	06ElyPond1 RA	<0.6	<1	2.7	0.16	21.8	<0.02	0.02	<0.2	30.4	<0.1	0.005	<0.1	1.4	<0.5	0.4
EM-POND2	06ElyPond2 FA	<0.6	<1	3.9	<0.01	29.5	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	<0.1	<0.5	<0.5	0.05
EM-POND2	06ElyPond2 RA	0.6	<1	4.3	0.02	31.9	<0.02	0.005	<0.2	2.2	<0.1	<0.005	<0.1	<0.5	<0.5	0.1
EM-POND3	06ElyPond3 FA	0.6	<1	4.5	0.01	34.8	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	<0.1	<0.5	0.51	0.04
EM-POND3	06ElyPond3 RA	0.7	<1	4.7	0.02	36.1	<0.02	<0.005	<0.2	1	<0.1	<0.005	<0.1	<0.5	<0.5	0.08
EM-POND4	06ElyPond4 FA	0.7	<1	4.7	0.01	38.2	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	<0.1	<0.5	<0.5	0.06
EM-POND4	06ElyPond4 RA	0.7	<1	4.9	0.03	39.6	<0.02	0.005	<0.2	1.9	<0.1	<0.005	<0.1	<0.5	<0.5	0.12
EM-POND5	06ElyPond5 FA	0.9	<1	7	0.22	43.4	<0.02	0.03	<0.2	<0.5	<0.1	0.007	<0.1	<0.5	<0.5	0.88
EM-POND5	06ElyPond5 RA	0.9	<1	6.7	0.45	43.3	<0.02	0.063	<0.2	0.7	<0.1	0.02	<0.1	<0.5	<0.5	1.37
EM-POND6	06ElyPond6 FA	1.1	<1	8.3	2.09	50.4	<0.02	0.29	<0.2	0.9	<0.1	0.072	0.2	<0.5	0.53	5.91
EM-POND6	06ElyPond6 RA	1	<1	8	2.24	52.6	<0.02	0.31	<0.2	1.9	<0.1	0.076	0.22	5.1	<0.5	6.16

Appendix 6. Constituents in surface waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level]

Site No.	Previous sample ID	Yb (µg/L) ICP-MS	Zn (µg/L) ICP-MS	Zr (µg/L) ICP-MS	Job No. IC	Lab No. IC	Field No. IC	Cl (mg/L) IC	F (mg/L) IC	NO_3 (mg/L) IC	SO_4 (mg/L) IC	Job No. CVAF	Lab No. CVAF	Field No. CVAF	Hg (ng/L) CVAF
EB-1080M	06Ely01A FA	<0.005	5.6	<0.2	MRP-07540	C-289414	06Ely01A FU	1.4	<.08	<.08	4.3	MRP-07542	C-289490	06Ely01A Hg	<5
EB-1080M	06Ely01A RA	0.006	16.4	<0.2	—	—	—	—	—	—	—	—	—	—	—
EB-770M	06Ely02A FA	0.14	114	<0.2	MRP-07540	C-289416	06Ely02A FU	1.4	0.1	0.5	52	MRP-07542	C-289492	06Ely02A Hg	<5
EB-770M	06Ely02A RA	0.3	109	<0.2	—	—	—	—	—	—	—	—	—	—	—
EB-600M	06Ely03A FA	0.02	64.2	<0.2	MRP-07540	C-289418	06Ely03A FU	1.5	0.1	0.5	36	MRP-07542	C-289494	06Ely03A Hg	<5
EB-600M	06Ely03A RA	0.11	54.9	<0.2	—	—	—	—	—	—	—	—	—	—	—
EB-90M	06Ely04A FA	0.5	373	<0.2	MRP-07540	C-289420	06Ely04A FU	2.6	0.5	1	143	MRP-07542	C-289496	06Ely04A Hg	<5
EB-90M	06Ely04A RA	0.52	342	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-3670M	06Ely05A FA	<0.005	2.8	<0.2	MRP-07540	C-289422	06Ely05A FU	4.2	0.3	0.6	9	MRP-07542	C-289498	06Ely05A Hg	<5
SB-3670M	06Ely05A RA	<0.005	2.8	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-3125M	06Ely19A FA	0.007	15.6	<0.2	MRP-07540	C-289425	06Ely19A FU	4.6	0.09	0.6	13	MRP-07542	C-289501	06Ely19A Hg	<5
SB-3125M	06Ely19A RA	0.04	24.7	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-2400M	06Ely06A FA	<0.005	6.6	<0.2	MRP-07540	C-289428	06Ely06A FU	5	<.08	0.6	16	MRP-07542	C-289504	06Ely06A Hg	<5
SB-2400M	06Ely06A RA	0.02	15.8	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-1360M	06Ely07A FA	<0.005	19.8	<0.2	MRP-07540	C-289431	06Ely07A FU	4.6	<.08	0.5	14	MRP-07542	C-289507	06Ely07A Hg	<5
SB-1360M	06Ely07A RA	0.02	13	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-140M	06Ely08A FA	<0.005	12.8	<0.2	MRP-07540	C-289433	06Ely08A FU	4	<.08	0.5	13	MRP-07542	C-289509	06Ely08A Hg	<5
SB-140M	06Ely08A RA	0.02	10.3	<0.2	—	—	—	—	—	—	—	—	—	—	—
OR-24050M	06Ely09A FA	<0.005	9.3	<0.2	MRP-07540	C-289435	06Ely09A FU	5.7	<.08	0.6	7.2	MRP-07542	C-289511	06Ely09A Hg	<5
OR-24050M	06Ely09A RA	0.02	16.3	<0.2	—	—	—	—	—	—	—	—	—	—	—
OR-23630M	06Ely20A FA	<0.005	12.5	<0.2	MRP-07540	C-289437	06Ely20A FU	6	<.08	0.6	8	MRP-07542	C-289513	06Ely20A Hg	<5
OR-23630M	06Ely20A RA	0.01	3	<0.2	—	—	—	—	—	—	—	—	—	—	—
OR-23200M	06Ely10A FA	<0.005	6.9	<0.2	MRP-07540	C-289438	06Ely10A FU	5.4	0.1	0.5	8	MRP-07542	C-289514	06Ely10A Hg	<5
OR-23200M	06Ely10A RA	0.01	3.3	<0.2	—	—	—	—	—	—	—	—	—	—	—
EM-POND1	06ElyPond1 FA	<0.005	2.3	<0.2	MRP-07597	C-290567	06ElyPond1 FU	0.11	<.08	<.08	6.3	—	—	—	—
EM-POND1	06ElyPond1 RA	0.03	3	<0.2	—	—	—	—	—	—	—	—	—	—	—
EM-POND2	06ElyPond2 FA	<0.005	11.5	<0.2	MRP-07597	C-290568	06ElyPond2 FU	1.4	0.1	0.6	5.4	—	—	—	—
EM-POND2	06ElyPond2 RA	0.008	1.1	<0.2	—	—	—	—	—	—	—	—	—	—	—
EM-POND3	06ElyPond3 FA	0.006	2.4	<0.2	MRP-07597	C-290569	06ElyPond3 FU	1.3	<.08	0.6	5	—	—	—	—
EM-POND3	06ElyPond3 RA	0.008	0.8	<0.2	—	—	—	—	—	—	—	—	—	—	—
EM-POND4	06ElyPond4 FA	<0.005	14.8	<0.2	MRP-07597	C-290570	06ElyPond4 FU	0.21	0.1	<.08	8.1	—	—	—	—
EM-POND4	06ElyPond4 RA	0.01	17.7	<0.2	—	—	—	—	—	—	—	—	—	—	—
EM-POND5	06ElyPond5 FA	0.04	143	<0.2	MRP-07597	C-290571	06ElyPond5 FU	1.3	0.1	0.6	33	—	—	—	—
EM-POND5	06ElyPond5 RA	0.1	143	<0.2	—	—	—	—	—	—	—	—	—	—	—
EM-POND6	06ElyPond6 FA	0.43	325	<0.2	MRP-07597	C-290572	06ElyPond6 FU	0.2	0.4	0.6	93	—	—	—	—
EM-POND6	06ElyPond6 RA	0.46	328	<0.2	—	—	—	—	—	—	—	—	—	—	—

[a] Estimated value, reported concentration is less than the reporting level but greater than the long-term method-detection level.

Appendix 7. Constituents in pore waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level; ins, insufficient sample]

Site No.	Previous sample ID	Split	Sample type	Date	pH	S.C. (µS/cm)	Alkalinity (mg/L as $CaCO_3$)	DOC (mg/L)	Ammonia (mg/L as N)	Nitrite (mg/L as N)	NO_2+NO_3 (mg/L as N)	Total N (mg/L)	Phosphorus (mg/L)	Orthophosphate (mg/L as P)	Job. No. ICP-AES & ICP-MS
EB-1080M	06Ely01B FA	filtered	in situ	8/23/2006	7.1	85	40	1.6	<0.01	<0.002	<0.06	0.08	0.003 E[a]	0.005 E	MRP-07541
EB-1080M	06Ely01B RA	raw	in situ	8/23/2006	7.1	85	—	—	—	—	—	—	—	—	MRP-07541
EB-1080M	06Ely01C FA	filtered	centrifuge	8/23/2006	—	—	—	—	—	—	—	—	—	—	MRP-07596
EB-1080M	06Ely01D FA	filtered	equilbrated	9/20/2006	7.5	389	204.8	—	—	—	—	—	—	—	MRP-07596
EB-770M	06Ely02B FA	filtered	in situ	8/23/2006	6.1	131	11	1	0.009 E	<0.002	<0.06	0.04 E	<0.004	0.005 E	MRP-07541
EB-770M	06Ely02B RA	raw	in situ	8/23/2006	6.1	131	—	—	—	—	—	—	—	—	MRP-07541
EB-770M	06Ely02C FA	filtered	centrifuge	8/23/2006	—	—	—	—	—	—	—	—	—	—	MRP-07596
EB-770M	06Ely02D FA	filtered	equilbrated	9/20/2006	6.0	400	39.6	—	—	—	—	—	—	—	MRP-07596
EB-600M	06Ely03B FA	filtered	in situ	8/23/2006	6.9	119	15	1	<0.01	<0.002	<0.06	0.05 E	0.004 E	0.005 E	MRP-07541
EB-600M	06Ely03B RA	raw	in situ	8/23/2006	6.9	119	—	—	—	—	—	—	—	—	MRP-07541
EB-600M	06Ely03C FA	filtered	centrifuge	8/23/2006	—	—	—	—	—	—	—	—	—	—	MRP-07596
EB-600M	06Ely03D FA	filtered	equilbrated	9/20/2006	7.0	164.2	30.4	—	—	—	—	—	—	—	MRP-07596
EB-90M	06Ely04B FA	filtered	in situ	8/23/2006	2.9	594	—	1.3	0.1	<0.002	<0.06	0.17	0.004	0.009	MRP-07543
EB-90M	06Ely04B RA	raw	in situ	8/23/2006	2.9	594	—	—	—	—	—	—	—	—	MRP-07543
EB-90M	06Ely04C FA	filtered	centrifuge	8/23/2006	—	—	—	—	—	—	—	—	—	—	MRP-07596
EB-90M	06Ely04D FA	filtered	equilbrated	9/20/2006	3.2	1,063	—	—	—	—	—	—	—	—	MRP-07596
SB-3670M	06Ely05B FA	filtered	in situ	8/22/2006	7.7	251	116	1.5	<0.01	0.002 E	<0.06	0.07	0.004	0.004 E	MRP-07543
SB-3670M	06Ely05B RA	raw	in situ	8/22/2006	7.7	251	—	—	—	—	—	—	—	—	MRP-07543
SB-3670M	06Ely05C FA	filtered	centrifuge	8/22/2006	—	—	—	—	—	—	—	—	—	—	MRP-07596
SB-3670M	06Ely05D FA	filtered	equilbrated	9/19/2006	7.8	561	284	—	—	—	—	—	—	—	MRP-07596
SB-2400M	06Ely06B FA	filtered	in situ	8/22/2006	7.7	347	126	1	0.029	0.002 E	<0.06	0.09	0.006	0.006	MRP-07543
SB-2400M	06Ely06B RA	raw	in situ	8/22/2006	7.7	347	—	—	—	—	—	—	—	—	MRP-07543
SB-2400M	06Ely06C FA	filtered	centrifuge	8/22/2006	—	—	—	—	—	—	—	—	—	—	MRP-07596
SB-2400M	06Ely06D FA	filtered	equilbrated	9/19/2006	7.6	563	172.8	—	—	—	—	—	—	—	MRP-07596
SB-1360M	06Ely07B FA	filtered	in situ	8/23/2006	7.7	218	92	1.6	0.036	0.006	0.11	0.24	0.006	0.006 E	MRP-07543
SB-1360M	06Ely07B RA	raw	in situ	8/23/2006	7.7	218	—	—	—	—	—	—	—	—	MRP-07543
SB-1360M	06Ely07C FA	filtered	centrifuge	8/23/2006	—	—	—	—	—	—	—	—	—	—	MRP-07596
SB-1360M	06Ely07D FA	filtered	equilbrated	9/20/2006	7.4	523	190.4	—	—	—	—	—	—	—	MRP-07596
SB-140M	06Ely08B FA	filtered	in situ	8/21/2006	7.6	260	107	0.9	<0.01	<0.002	0.11	0.15	0.004 E	0.004 E	MRP-07543
SB-140M	06Ely08B RA	raw	in situ	8/21/2006	7.6	260	—	—	—	—	—	—	—	—	MRP-07543
SB-140M	06Ely08C FA	filtered	centrifuge	8/22/2006	—	—	—	—	—	—	—	—	—	—	MRP-07596
SB-140M	06Ely08D FA	filtered	equilbrated	9/19/2006	7.4	531	212.4	—	—	—	—	—	—	—	MRP-07596
OR-24050M	06Ely09B FA	filtered	in situ	8/21/2006	7.6	359	150	1.4	0.051	0.039	0.85	1.04	0.006	0.006	MRP-07543
OR-24050M	06Ely09B RA	raw	in situ	8/21/2006	7.6	359	—	—	—	—	—	—	—	—	MRP-07543
OR-24050M	06Ely09C FA	filtered	centrifuge	8/22/2006	—	—	—	—	—	—	—	—	—	—	MRP-07596
OR-24050M	06Ely09D FA	filtered	equilbrated	9/19/2006	7.9	709	—	—	—	—	—	—	—	—	MRP-07596
OR-23200M	06Ely10B FA	filtered	in situ	8/21/2006	7.6	277	105	1.4	0.077	0.005	0.04 E	0.2	0.005	0.004 E	MRP-07543
OR-23200M	06Ely10B RA	raw	in situ	8/21/2006	7.6	277	—	—	—	—	—	—	—	—	MRP-07543
OR-23200M	06Ely10C FA	filtered	centrifuge	8/22/2006	—	—	—	—	—	—	—	—	—	—	MRP-07596
OR-23200M	06Ely10D FA	filtered	equilbrated	9/19/2006	7.4	535	250.8	—	—	—	—	—	—	—	MRP-07596

Appendix 7. Constituents in pore waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level; ins, insufficient sample]

Site No.	Previous sample ID	Lab No. ICP-AES & ICP-MS	Ag (µg/L) ICP-AES	Al (µg/L) ICP-AES	As (µg/L) ICP-AES	B (µg/L) ICP-AES	Ba (µg/L) ICP-AES	Be (µg/L) ICP-AES	Ca (mg/L) ICP-AES	Cd (µg/L) ICP-AES	Co (µg/L) ICP-AES	Cr (µg/L) ICP-AES	Cu (µg/L) ICP-AES	Fe (µg/L) ICP-AES	K (mg/L) ICP-AES	Li (µg/L) ICP-AES
EB-1080M	06Ely01B FA	C-289448	<5	<20	<200	<5	19	<10	12.6	<5	<10	<10	<10	<20	1.68	<5
EB-1080M	06Ely01B RA	C-289449	<5	<20	<200	<5	18	<10	13	<5	<10	<10	<10	38	1.69	<5
EB-1080M	06Ely01C FA	C-290543	<5	135	<200	<5	42	<10	28	<5	<10	<10	12	436	2.78	<5
EB-1080M	06Ely01D FA	C-290544	<5	<20	<200	<5	89	<10	69.5	<5	<10	<10	<10	<20	4.84	<5
EB-770M	06Ely02B FA	C-289461	<5	<20	<200	<5	14	<10	14.3	<5	<10	<10	29	145	2.16	<5
EB-770M	06Ely02B RA	C-289462	<5	35	<200	<5	16	<10	15.6	<5	<10	<10	39	186	2.37	<5
EB-770M	06Ely02C FA	C-290545	<5	80	<200	<5	40	<10	32	<5	85	<10	54	32	3.45	<5
EB-770M	06Ely02D FA	C-290546	<5	<20	<200	6.2	86	<10	56.1	<5	95	<10	131	747	7.32	<5
EB-600M	06Ely03B FA	C-289455	<5	<20	<200	<5	19	<10	14.4	<5	<10	<10	45	<20	2.13	<5
EB-600M	06Ely03B RA	C-289456	<5	216	<200	<5	20	<10	14.8	<5	<10	<10	87	212	2.2	<5
EB-600M	06Ely03C FA	C-290539	<5	456	<200	<5	22	<10	16.8	<5	<10	<10	125	52	2.6	5.8
EB-600M	06Ely03D FA	C-290540	<5	<20	<200	<5	31	<10	21.6	<5	10	<10	68	<20	4.04	5.8
EB-90M	06Ely04B FA	C-289554	<5	4,830	<200	<5	21	<10	20.4	<5	74	<10	2,180	11,000	4.87	15
EB-90M	06Ely04B RA	C-289555	<5	4,990	<200	<5	22	<10	21	<5	76	<10	2,240	12,000	5.04	15
EB-90M	06Ely04C FA	C-290562	<5	8,760	<200	<5	28	<10	29.1	<5	75	<10	2,030	163,100	10.3	33
EB-90M	06Ely04D FA	C-290563	<5	10,000	<200	<5	25	<10	28.7	<5	299	<10	2,640	47,000	5.24	22
SB-3670M	06Ely05B FA	C-289529	<5	<20	<200	<5	26	<10	41.2	<5	<10	<10	<10	<20	2.48	<5
SB-3670M	06Ely05B RA	C-289530	<5	42	<200	<5	27	<10	42.1	<5	<10	<10	<10	24	2.57	<5
SB-3670M	06Ely05C FA	C-290554	<5	98	<200	5.3	47	<10	64.5	<5	<10	<10	<10	101	3.48	<5
SB-3670M	06Ely05D FA	C-290555	5.4	<20	<200	5.9	82	<10	104	<5	<10	<10	<10	<20	5.02	<5
SB-2400M	06Ely06B FA	C-289539	<5	<20	<200	<5	29	<10	46.6	<5	<10	<10	<10	<20	4.09	<5
SB-2400M	06Ely06B RA	C-289540	<5	26	<200	<5	29	<10	47.2	<5	<10	<10	11	28	4.15	<5
SB-2400M	06Ely06C FA	C-290556	<5	202	<200	31	40	<10	68.8	<5	<10	<10	16	213	4.22	<5
SB-2400M	06Ely06D FA	C-290557	<5	45	<200	6.9	67	<10	92.1	<5	<10	<10	22	30	7.19	<5
SB-1360M	06Ely07B FA	C-289525	<5	<20	<200	<5	20	<10	34.6	<5	<10	<10	<10	<20	2.81	<5
SB-1360M	06Ely07B RA	C-289526	<5	82	<200	<5	21	<10	36.3	<5	<10	<10	11	54	2.94	<5
SB-1360M	06Ely07C FA	C-290548	<5	74	<200	<5	32	<10	52.1	<5	<10	<10	17	79	3.64	<5
SB-1360M	06Ely07D FA	C-290549	<5	20	<200	7.1	79	<10	93.6	<5	<10	<10	25	<20	7.39	<5
SB-140M	06Ely08B FA	C-289535	<5	<20	<200	<5	26	<10	39.9	<5	<10	<10	<10	<20	2.71	<5
SB-140M	06Ely08B RA	C-289536	<5	28	<200	<5	27	<10	41.1	<5	<10	<10	<10	<20	2.78	<5
SB-140M	06Ely08C FA	C-290550	<5	<20	<200	5.7	45	<10	65.8	<5	<10	<10	<10	28	3.65	<5
SB-140M	06Ely08D FA	C-290551	<5	<20	<200	8.3	88	<10	101	<5	<10	<10	25	<20	7.31	<5
OR-24050M	06Ely09B FA	C-289543	<5	<20	<200	12	48	<10	51.6	<5	<10	<10	<10	<20	7.18	<5
OR-24050M	06Ely09B RA	C-289544	<5	27	<200	12	54	<10	51.7	<5	<10	<10	<10	<20	7.26	<5
OR-24050M	06Ely09C FA	C-290560	<5	<20	<200	14	69	<10	68.5	<5	<10	<10	<10	30	7.99	<5
OR-24050M	06Ely09D FA	C-290561	<5	<20	<200	15	143	<10	137	<5	<10	<10	<10	<20	12.9	<5
OR-23200M	06Ely10B FA	C-289537	<5	<20	<200	<5	23	<10	35.8	<5	<10	<10	<10	<20	3.18	<5
OR-23200M	06Ely10B RA	C-289538	<5	47	<200	<5	24	<10	36.6	<5	<10	<10	<10	47	3.24	<5
OR-23200M	06Ely10C FA	C-290552	<5	49	<200	<5	56	<10	68.9	<5	<10	<10	13	23	3.73	<5
OR-23200M	06Ely10D FA	C-290553	<5	<20	<200	6.3	85	<10	86.8	<5	<10	<10	17	<20	5.46	<5

Appendix 7. Constituents in pore waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level; ins, insufficient sample]

Site No.	Previous sample ID	Mg (mg/L) ICP-AES	Mn (µg/L) ICP-AES	Mo (µg/L) ICP-AES	Na (mg/L) ICP-AES	Ni (µg/L) ICP-AES	P (mg/L) ICP-AES	Pb (µg/L) ICP-AES	Sb (µg/L) ICP-AES	SiO_2 (mg/L) ICP-AES	SO_4 (mg/L) ICP-AES	Sr (µg/L) ICP-AES	Ti (µg/L) ICP-AES	V (µg/L) ICP-AES	Zn (µg/L) ICP-AES	Ag (µg/L) ICP-MS
EB-1080M	06Ely01B FA	1.18	<10	<20	1.13	<10	<0.5	<50	<50	9	4	49	<50	<10	<20	<3
EB-1080M	06Ely01B RA	1.18	<10	<20	1.11	<10	<0.5	<50	<50	9.1	4.1	49	<50	<10	<20	<3
EB-1080M	06Ely01C FA	2.53	57	<20	1.71	<10	<0.5	<50	<50	9.7	10.7	114	<50	<10	33	<3
EB-1080M	06Ely01D FA	6.42	3,000	<20	2.79	<10	<0.5	<50	<50	12.7	15.8	258	<50	<10	<20	<3
EB-770M	06Ely02B FA	2.41	46	<20	1.41	<10	<0.5	<50	<50	12.8	40.7	53	<50	<10	25	<3
EB-770M	06Ely02B RA	2.65	51	<20	1.51	<10	<0.5	<50	<50	14	44.3	58	<50	<10	24	<3
EB-770M	06Ely02C FA	5.38	3,510	<20	1.95	15	<0.5	<50	<50	15	97.6	124	<50	<10	59	<3
EB-770M	06Ely02D FA	9.29	6,590	<20	3.51	24	<0.5	<50	<50	25.3	170	212	<50	<10	126	<3
EB-600M	06Ely03B FA	2.29	17	<20	1.4	<10	<0.5	<50	<50	13	36.2	51	<50	<10	26	<3
EB-600M	06Ely03B RA	2.38	22	<20	1.43	<10	<0.5	<50	<50	13.6	36.7	53	<50	<10	28	<3
EB-600M	06Ely03C FA	2.56	31	<20	1.47	<10	<0.5	<50	<50	12.4	39.6	58	<50	<10	28	<3
EB-600M	06Ely03D FA	3.16	495	<20	2.4	<10	<0.5	<50	<50	15.9	48.7	87	<50	<10	27	<3
EB-90M	06Ely04B FA	5.43	606	<20	2.34	21	<0.5	<50	<50	32.8	162	65	<50	<10	345	<3
EB-90M	06Ely04B RA	5.58	623	<20	2.4	21	<0.5	<50	<50	33.6	166	67	<50	<10	350	<3
EB-90M	06Ely04C FA	8.58	3,470	<20	5.42	46	<0.5	<50	<50	69.8	515	114	<50	<10	643	<3
EB-90M	06Ely04D FA	7.61	3,310	<20	4.23	36	<0.5	<50	<50	39.5	280	97	<50	<10	577	<3
SB-3670M	06Ely05B FA	1.88	<10	<20	4.12	<10	<0.5	<50	<50	7.6	8.9	198	<50	<10	<20	<3
SB-3670M	06Ely05B RA	1.94	<10	<20	4.2	<10	<0.5	<50	<50	7.8	8.9	205	<50	<10	<20	<3
SB-3670M	06Ely05C FA	2.61	<10	<20	4.69	<10	<0.5	<50	<50	10	15.4	298	<50	<10	<20	<3
SB-3670M	06Ely05D FA	4.29	4,000	<20	6.33	<10	<0.5	<50	<50	11.8	17.8	475	<50	<10	<20	<3
SB-2400M	06Ely06B FA	3.19	117	<20	16.2	<10	<0.5	<50	<50	10.3	21	219	<50	<10	<20	<3
SB-2400M	06Ely06B RA	3.23	118	<20	16.3	<10	<0.5	<50	<50	10.3	20.9	222	<50	<10	<20	<3
SB-2400M	06Ely06C FA	6.21	165	<20	15.4	<10	<0.5	<50	<50	11.8	43.7	317	<50	<10	<20	<3
SB-2400M	06Ely06D FA	5.26	1,140	<20	15.3	<10	<0.5	<50	<50	16.5	108	447	<50	<10	<20	<3
SB-1360M	06Ely07B FA	1.95	33	<20	3.78	<10	<0.5	<50	<50	8.8	16.3	174	<50	<10	<20	<3
SB-1360M	06Ely07B RA	2.07	37	<20	3.94	<10	<0.5	<50	<50	9.4	17	183	<50	<10	<20	<3
SB-1360M	06Ely07C FA	3.16	183	<20	4.47	<10	<0.5	<50	<50	10	34.1	242	<50	<10	<20	<3
SB-1360M	06Ely07D FA	5.7	2,030	<20	6.74	<10	<0.5	<50	<50	16.4	95.8	464	<50	<10	<20	<3
SB-140M	06Ely08B FA	2.02	<10	<20	6.03	<10	<0.5	<50	<50	8.1	16	184	<50	<10	<20	<3
SB-140M	06Ely08B RA	2.07	<10	<20	6.18	<10	<0.5	<50	<50	8.4	16.3	189	<50	<10	<20	<3
SB-140M	06Ely08C FA	3.18	233	<20	5.54	<10	<0.5	<50	<50	9.4	24.6	296	<50	<10	<20	<3
SB-140M	06Ely08D FA	5.66	1,400	<20	9.68	<10	<0.5	<50	<50	15.8	75.8	470	<50	<10	<20	<3
OR-24050M	06Ely09B FA	2.99	205	<20	10.9	<10	<0.5	<50	<50	9.8	9.1	241	<50	<10	<20	<3
OR-24050M	06Ely09B RA	3.03	207	<20	11	<10	<0.5	<50	<50	9.9	9.2	243	<50	<10	<20	<3
OR-24050M	06Ely09C FA	4.05	<10	<20	12.6	<10	<0.5	<50	<50	10.6	16.2	318	<50	<10	24	ins
OR-24050M	06Ely09D FA	7.78	6,830	<20	16.5	<10	<0.5	<50	<50	16.1	12	627	<50	<10	<20	<3
OR-23200M	06Ely10B FA	1.47	364	<20	14.9	<10	<0.5	<50	<50	7.8	11.6	165	<50	<10	<20	<3
OR-23200M	06Ely10B RA	1.51	373	<20	15.2	<10	<0.5	<50	<50	8.2	11.8	169	<50	<10	<20	<3
OR-23200M	06Ely10C FA	3.51	1,690	<20	10.6	<10	<0.5	<50	<50	8.1	22.3	308	<50	<10	<20	<3
OR-23200M	06Ely10D FA	4.04	3,700	<20	16.8	<10	<0.5	<50	<50	14.5	28.1	399	<50	<10	<20	<3

Appendix 7. Constituents in pore waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level; ins, insufficient sample]

Site No.	Previous sample ID	Al (µg/L) ICP-MS	As (µg/L) ICP-MS	Ba (µg/L) ICP-MS	Be (µg/L) ICP-MS	Bi (µg/L) ICP-MS	Ca (mg/L) ICP-MS	Cd (µg/L) ICP-MS	Ce (µg/L) ICP-MS	Co (µg/L) ICP-MS	Cr (µg/L) ICP-MS	Cs (µg/L) ICP-MS	Cu (µg/L) ICP-MS	Dy (µg/L) ICP-MS	Er (µg/L) ICP-MS	Eu (µg/L) ICP-MS	Fe (µg/L) ICP-MS	Ga (µg/L) ICP-MS
EB-1080M	06Ely01B FA	4.3	<1	16.6	<0.05	<0.2	11	<0.02	0.03	<0.02	<1	<0.02	2.4	0.007	<0.005	<0.005	<50	<0.05
EB-1080M	06Ely01B RA	26.6	<1	16.5	<0.05	<0.2	11.5	<0.02	0.08	0.03	<1	0.02	2.3	0.01	0.006	0.006	<50	<0.05
EB-1080M	06Ely01C FA	88.8	<1	33.4	<0.05	<0.2	20.7	1.66	1.31	0.46	<1	0.06	10.2	0.1	0.051	0.03	345	0.05
EB-1080M	06Ely01D FA	12.2	<1	74.7	<0.05	<0.2	56.8	0.11	0.05	0.55	<1	0.15	4.3	0.007	0.005	0.01	<50	0.06
EB-770M	06Ely02B FA	4.8	<1	12.9	<0.05	<0.2	11.7	0.28	0.23	2.36	<1	0.02	27.4	0.02	0.01	0.006	97	<0.05
EB-770M	06Ely02B RA	26	<1	13.7	<0.05	<0.2	12.6	0.28	0.41	2.56	<1	0.03	36.7	0.02	0.02	0.009	132	<0.05
EB-770M	06Ely02C FA	50.4	<1	31.9	<0.05	<0.2	23	1.25	0.56	61.7	<1	0.05	43.4	0.04	0.02	0.02	<50	0.06
EB-770M	06Ely02D FA	7	<1	64.5	<0.05	<0.2	41.6	1.95	1.22	71.3	<1	0.13	106	0.093	0.05	0.04	576	0.1
EB-600M	06Ely03B FA	7.1	<1	17	<0.05	<0.2	12.2	0.3	0.17	2.37	<1	0.03	42.7	0.02	0.01	0.006	<50	<0.05
EB-600M	06Ely03B RA	177	<1	17.3	<0.05	<0.2	12	0.32	0.74	2.64	<1	0.05	79.4	0.07	0.03	0.02	199	<0.05
EB-600M	06Ely03C FA	345	<1	19.8	<0.05	<0.2	13.7	0.34	1	2.15	<1	0.05	108	0.14	0.058	0.04	<50	<0.05
EB-600M	06Ely03D FA	15.4	<1	26.7	<0.05	<0.2	16.8	0.59	0.37	8.24	<1	0.11	59.6	0.02	0.01	0.01	91	<0.05
EB-90M	06Ely04B FA	3060	<1	17.8	0.3	<0.2	15.6	1.85	22.7	57.9	1.4	0.98	1,800	1.54	0.65	0.46	9,560	0.2
EB-90M	06Ely04B RA	3010	<1	17.7	0.2	<0.2	15.3	1.84	23.4	57.8	1.4	0.95	1,810	1.58	0.7	0.48	9,580	0.2
EB-90M	06Ely04C FA	7520	<1	20.6	0.3	<0.2	22.8	2.87	48.6	272	2.1	1.11	2,140	3.16	1.44	0.88	41,100	0.51
EB-90M	06Ely04D FA	6050	<1	21.8	0.5	<0.2	24.2	2.62	66.3	246	1.4	3.32	1,700	3.68	1.61	1.14	148,000	0.61
SB-3670M	06Ely05B FA	6.1	<1	23.8	<0.05	<0.2	38.2	<0.02	0.01	<0.02	<1	0.08	<0.5	<0.005	<0.005	<0.005	<50	<0.05
SB-3670M	06Ely05B RA	37.2	<1	24.2	<0.05	<0.2	39.1	<0.02	0.07	<0.02	<1	0.09	<0.5	0.006	<0.005	0.005	<50	<0.05
SB-3670M	06Ely05C FA	94.1	<1	42.5	<0.05	<0.2	60.7	0.04	0.2	0.12	<1	0.2	1	0.02	0.006	0.009	94	<0.05
SB-3670M	06Ely05D FA	16.3	<1	75.7	<0.05	<0.2	107	0.04	0.14	0.68	<1	0.34	2.9	0.01	0.008	0.01	<50	0.1
SB-2400M	06Ely06B FA	12.8	<1	26.4	<0.05	<0.2	44.9	0.08	0.02	0.28	<1	0.15	7.9	<0.005	<0.005	<0.005	<50	<0.05
SB-2400M	06Ely06B RA	28.6	<1	26.9	<0.05	<0.2	44.9	0.07	0.08	0.33	<1	0.16	12	0.007	0.005	0.006	<50	<0.05
SB-2400M	06Ely06C FA	197	<1	35.4	<0.05	<0.2	63.9	0.15	0.22	1.1	<1	0.25	16.8	0.02	0.01	0.01	197	0.06
SB-2400M	06Ely06D FA	38.2	<1	60.1	<0.05	<0.2	84.8	0.3	0.1	2.44	<1	0.42	22.8	0.008	<0.005	0.01	<50	<0.05
SB-1360M	06Ely07B FA	15	<1	18.2	<0.05	<0.2	31.2	0.05	0.03	0.13	<1	0.1	9.6	0.005	<0.005	<0.005	<50	<0.05
SB-1360M	06Ely07B RA	69.6	<1	18.8	<0.05	<0.2	30.8	0.04	0.16	0.19	<1	0.11	10.2	0.01	0.007	0.005	<50	<0.05
SB-1360M	06Ely07C FA	76.8	<1	29.2	<0.05	<0.2	50.6	0.17	0.15	1.59	<1	0.18	18.1	0.01	0.006	0.005	75	<0.05
SB-1360M	06Ely07D FA	8.5	<1	68.8	<0.05	<0.2	84.3	0.27	0.07	4.28	<1	0.36	24.9	0.006	<0.005	0.01	<50	<0.05
SB-140M	06Ely08B FA	11.4	<1	23.4	<0.05	<0.2	37.4	0.04	<0.01	0.03	<1	0.08	5.6	<0.005	<0.005	<0.005	<50	<0.05
SB-140M	06Ely08B RA	22	<1	24	<0.05	<0.2	38.3	0.04	0.03	0.05	<1	0.08	6.5	<0.005	<0.005	<0.005	<50	<0.05
SB-140M	06Ely08C FA	14	<1	38.9	<0.05	<0.2	58.7	0.22	0.07	1.05	<1	0.15	8.5	0.007	<0.005	0.007	<50	<0.05
SB-140M	06Ely08D FA	10.7	<1	69	<0.05	<0.2	83.1	0.4	0.08	3.81	<1	0.3	21.6	0.005	0.005	0.01	<50	<0.05
OR-24050M	06Ely09B FA	5.4	<1	43.3	<0.05	<0.2	48.1	<0.02	0.02	0.03	<1	0.11	0.56	<0.005	<0.005	0.006	<50	<0.05
OR-24050M	06Ely09B RA	29.8	<1	49.5	<0.05	<0.2	49.4	<0.02	0.06	0.03	<1	0.12	0.6	0.005	0.005	0.005	<50	<0.05
OR-24050M	06Ely09C FA	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins
OR-24050M	06Ely09D FA	21.5	<1	126	<0.05	<0.2	131	0.04	0.21	0.74	<1	0.3	1.6	0.02	0.009	0.02	<50	0.1
OR-23200M	06Ely10B FA	12.9	<1	21.6	<0.05	<0.2	33.4	0.06	0.04	0.47	1.9	0.1	4.5	<0.005	<0.005	<0.005	184	<0.05
OR-23200M	06Ely10B RA	53.2	<1	22.4	<0.05	<0.2	34.1	0.07	0.13	0.47	<1	0.11	5.8	0.009	0.005	<0.005	<50	<0.05
OR-23200M	06Ely10C FA	38.5	<1	48.2	<0.05	<0.2	60.7	0.19	0.14	3.08	<1	0.25	14.2	0.009	0.006	0.01	<50	0.06
OR-23200M	06Ely10D FA	11.6	<1	77.5	<0.05	<0.2	84	0.09	0.07	2.08	<1	0.26	19.1	0.008	0.005	0.01	<50	0.07

Appendix 7. Constituents in pore waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level; ins, insufficient sample]

Site No.	Previous sample ID	Gd (µg/L) ICP-MS	Ge (µg/L) ICP-MS	Ho (µg/L) ICP-MS	K (mg/L) ICP-MS	La (µg/L) ICP-MS	Li (µg/L) ICP-MS	Lu (µg/L) ICP-MS	Mg (mg/L) ICP-MS	Mn (µg/L) ICP-MS	Mo (µg/L) ICP-MS	Na (mg/L) ICP-MS	Nb (µg/L) ICP-MS	Nd (µg/L) ICP-MS	Ni (µg/L) ICP-MS	P (mg/L) ICP-MS	Pb (µg/L) ICP-MS	Pr (µg/L) ICP-MS	Rb (µg/L) ICP-MS
EB-1080M	06Ely01B FA	0.01	<0.05	<0.005	1.4	0.04	0.2	<0.1	0.95	0.3	<2	0.93	<0.2	0.05	0.6	<0.01	0.06	0.01	3.46
EB-1080M	06Ely01B RA	0.02	<0.05	<0.005	1.47	0.07	<0.1	<0.1	0.99	2	<2	0.97	<0.2	0.08	<0.4	<0.01	<0.05	0.02	3.56
EB-1080M	06Ely01C FA	0.15	<0.05	0.02	2	0.74	0.2	<0.1	1.53	45.7	<2	1.11	<0.2	0.87	1.4	<0.01	0.91	0.21	7.56
EB-1080M	06Ely01D FA	0.01	<0.05	<0.005	3.94	0.05	0.2	<0.1	4.48	2,520	<2	2.06	<0.2	0.04	1.7	<0.01	<0.05	0.01	14.4
EB-770M	06Ely02B FA	0.02	<0.05	<0.005	1.79	0.13	1.2	<0.1	1.91	41.1	<2	1.12	<0.2	0.15	4.3	<0.01	0.2	0.03	5.76
EB-770M	06Ely02B RA	0.052	<0.05	0.005	1.9	0.21	1.5	<0.1	2.04	45.1	<2	1.18	<0.2	0.26	4.2	<0.01	<0.05	0.06	6.25
EB-770M	06Ely02C FA	0.071	<0.05	0.007	2.41	0.32	2.5	<0.1	3.3	2,780	<2	1.23	<0.2	0.38	12.6	<0.01	<0.05	0.08	10.3
EB-770M	06Ely02D FA	0.15	<0.05	0.02	5.24	0.93	2.3	<0.1	5.15	5,460	<2	2.03	<0.2	0.86	20	<0.01	<0.05	0.2	23
EB-600M	06Ely03B FA	0.03	<0.05	<0.005	1.8	0.14	2.2	<0.1	1.84	14.8	<2	1.16	<0.2	0.16	4	<0.01	<0.05	0.04	5.55
EB-600M	06Ely03B RA	0.094	<0.05	0.01	1.77	0.41	2.3	<0.1	1.87	19.3	<2	1.13	<0.2	0.52	4.1	0.01	0.1	0.11	5.69
EB-600M	06Ely03C FA	0.17	<0.05	0.02	2.12	0.61	3.2	<0.1	1.77	26.5	<2	1.07	<0.2	0.9	3.9	<0.01	0.08	0.2	6.71
EB-600M	06Ely03D FA	0.04	<0.05	<0.005	3.1	0.28	3.3	<0.1	2.04	418	<2	1.67	<0.2	0.28	4.5	<0.01	<0.05	0.06	12.8
EB-90M	06Ely04B FA	2.22	0.05	0.25	3.8	10.5	12.6	<0.1	3.47	501	<2	1.51	0.71	12	17.4	<0.01	1.9	3.01	20.1
EB-90M	06Ely04B RA	2.37	0.05	0.26	3.67	11	12.8	<0.1	3.36	502	<2	1.46	0.35	12.6	17.5	<0.01	1.9	3.14	20.6
EB-90M	06Ely04C FA	4.72	0.1	0.52	4.17	23.2	17.2	0.1	5.43	2,810	<2	3.02	<0.2	24	31.1	<0.01	1.2	5.95	25.1
EB-90M	06Ely04D FA	5.8	0.2	0.57	8.31	30.2	26.6	0.1	5.8	3,150	<2	3.57	<0.2	31.5	39	<0.01	1.7	7.9	60.4
SB-3670M	06Ely05B FA	<0.005	<0.05	<0.005	2.37	0.02	0.9	<0.1	1.68	0.4	<2	3.72	<0.2	0.01	<0.4	<0.01	0.06	<0.01	7.31
SB-3670M	06Ely05B RA	0.009	<0.05	<0.005	2.39	0.05	1.2	<0.1	1.75	1.9	<2	3.83	<0.2	0.04	<0.4	<0.01	<0.05	0.01	7.48
SB-3670M	06Ely05C FA	0.02	<0.05	<0.005	3.42	0.1	1.1	<0.1	2.39	6.8	<2	4.6	<0.2	0.11	2.4	0.02	0.1	0.02	13
SB-3670M	06Ely05D FA	0.01	<0.05	<0.005	5.32	0.08	0.2	<0.1	4.12	3,870	<2	6.41	<0.2	0.06	4.1	0.02	0.1	0.02	21
SB-2400M	06Ely06B FA	0.006	<0.05	<0.005	4.11	0.03	1.6	<0.1	3.11	113	<2	15.3	<0.2	0.02	0.5	<0.01	<0.05	<0.01	8.37
SB-2400M	06Ely06B RA	0.01	<0.05	<0.005	4.12	0.06	1.8	<0.1	3.14	114	<2	15.8	<0.2	0.06	0.5	<0.01	<0.05	0.01	8.43
SB-2400M	06Ely06C FA	0.02	<0.05	<0.005	4.08	0.12	2.2	<0.1	5.54	149	<2	14.1	<0.2	0.13	2.9	0.02	0.1	0.03	12.1
SB-2400M	06Ely06D FA	0.01	<0.05	<0.005	6.73	0.07	2	<0.1	4.5	1,030	<2	13.5	<0.2	0.07	2.6	<0.01	0.05	0.02	23.8
SB-1360M	06Ely07B FA	0.006	<0.05	<0.005	2.58	0.03	1.1	<0.1	1.7	31.5	<2	3.37	<0.2	0.03	0.8	<0.01	0.2	<0.01	7.74
SB-1360M	06Ely07B RA	0.01	<0.05	<0.005	2.56	0.09	1	<0.1	1.74	35.1	<2	3.36	<0.2	0.09	0.8	<0.01	0.08	0.02	7.88
SB-1360M	06Ely07C FA	0.02	<0.05	<0.005	3.62	0.08	1	<0.1	2.83	171	<2	4.19	<0.2	0.09	2.2	<0.01	0.09	0.02	11
SB-1360M	06Ely07D FA	0.01	<0.05	<0.005	6.65	0.06	1.9	<0.1	4.45	1,770	<2	5.62	<0.2	0.04	2.2	<0.01	<0.05	0.01	24
SB-140M	06Ely08B FA	0.005	<0.05	<0.005	2.7	0.02	1.7	<0.1	1.91	0.6	<2	5.78	<0.2	0.01	0.6	<0.01	0.2	<0.01	6.95
SB-140M	06Ely08B RA	<0.005	<0.05	<0.005	2.72	0.03	1.6	<0.1	1.95	1.2	<2	5.9	<0.2	0.03	<0.4	<0.01	0.07	<0.01	7.18
SB-140M	06Ely08C FA	0.008	<0.05	<0.005	3.26	0.04	1.1	<0.1	2.61	209	<2	4.79	<0.2	0.04	2.6	0.01	0.1	<0.01	12.3
SB-140M	06Ely08D FA	0.007	<0.05	<0.005	5.94	0.06	2.1	<0.1	4.04	1,100	<2	7.24	<0.2	0.04	2.2	<0.01	0.1	0.01	21.5
OR-24050M	06Ely09B FA	<0.005	<0.05	<0.005	7.17	0.02	0.7	<0.1	2.94	196	<2	11	<0.2	0.02	0.4	<0.01	<0.05	<0.01	3.47
OR-24050M	06Ely09B RA	0.006	<0.05	<0.005	7.36	0.04	0.9	<0.1	2.93	194	<2	11	<0.2	0.03	<0.4	0.01	<0.05	<0.01	3.46
OR-24050M	06Ely09C FA	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins
OR-24050M	06Ely09D FA	0.02	<0.05	<0.005	12.5	0.11	0.4	<0.1	7.44	6,270	<2	15.8	<0.2	0.09	3.8	0.02	0.09	0.02	5.51
OR-23200M	06Ely10B FA	0.006	<0.05	<0.005	3.08	0.03	1.1	<0.1	1.41	327	<2	14.8	<0.2	0.02	0.8	<0.01	0.3	<0.01	8.45
OR-23200M	06Ely10B RA	0.01	<0.05	<0.005	3.2	0.07	1.4	<0.1	1.43	341	<2	14.8	<0.2	0.06	0.5	<0.01	0.05	0.02	8.72
OR-23200M	06Ely10C FA	0.01	<0.05	<0.005	3.4	0.07	1.2	<0.1	2.99	1,500	<2	9.56	<0.2	0.07	2.8	0.01	0.09	0.02	14.4
OR-23200M	06Ely10D FA	0.006	<0.05	<0.005	5.44	0.04	1.7	<0.1	3.63	3,500	<2	15.5	<0.2	0.03	2.2	<0.01	0.2	<0.01	16.4

Appendix 7. Constituents in pore waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level; ins, insufficient sample]

Site No.	Previous sample ID	Sb (µg/L) ICP-MS	Sc (µg/L) ICP-MS	Se (µg/L) ICP-MS	SiO_2 (mg/L) ICP-MS	Sm (µg/L) ICP-MS	SO_4 (mg/L) ICP-MS	Sr (µg/L) ICP-MS	Ta (µg/L) ICP-MS	Tb (µg/L) ICP-MS	Th (µg/L) ICP-MS	Ti (µg/L) ICP-MS	Tl (µg/L) ICP-MS	Tm (µg/L) ICP-MS	U (µg/L) ICP-MS	V (µg/L) ICP-MS	W (µg/L) ICP-MS	Y (µg/L) ICP-MS	Yb (µg/L) ICP-MS
EB-1080M	06Ely01B FA	<0.3	0.6	<1	6.6	<0.01	<2	46.1	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	<0.1	<0.5	<0.5	0.04	<0.005
EB-1080M	06Ely01B RA	<0.3	0.6	<1	6.9	0.02	<2	47.8	0.03	<0.005	<0.2	1.4	<0.1	<0.005	<0.1	<0.5	<0.5	0.07	0.006
EB-1080M	06Ely01C FA	<0.3	0.8	<1	5.6	0.16	6	92.4	<0.02	0.02	<0.2	4	<0.1	0.005	<0.1	0.8	<0.5	0.48	0.04
EB-1080M	06Ely01D FA	<0.3	1.1	1.8	8.1	<0.01	11	225	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.49	<0.5	<0.5	0.04	<0.005
EB-770M	06Ely02B FA	<0.3	0.8	<1	9.4	0.03	33	51	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	<0.1	<0.5	<0.5	0.09	0.01
EB-770M	06Ely02B RA	<0.3	0.9	<1	9.9	0.06	35	54.9	<0.02	0.005	<0.2	1.1	<0.1	<0.005	<0.1	<0.5	<0.5	0.13	0.01
EB-770M	06Ely02C FA	<0.3	1.1	1.2	8.2	0.07	74	102	<0.02	0.007	<0.2	1.4	<0.1	<0.005	<0.1	<0.5	<0.5	0.2	0.02
EB-770M	06Ely02D FA	<0.3	1.8	1	13.1	0.15	134	195	<0.02	0.02	<0.2	1.8	<0.1	0.005	<0.1	<0.5	<0.5	0.48	0.04
EB-600M	06Ely03B FA	<0.3	0.8	<1	9.8	0.02	29	50.4	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	<0.1	<0.5	<0.5	0.09	0.005
EB-600M	06Ely03B RA	<0.3	0.8	<1	9.7	0.1	29	49.7	<0.02	0.01	<0.2	7.4	<0.1	<0.005	<0.1	<0.5	<0.5	0.31	0.03
EB-600M	06Ely03C FA	<0.3	1.1	<1	8.2	0.2	34	56.2	<0.02	0.02	<0.2	1.6	<0.1	0.007	<0.1	<0.5	<0.5	0.49	0.06
EB-600M	06Ely03D FA	<0.3	1.2	<1	9.6	0.05	39	71.9	<0.02	0.005	<0.2	0.6	<0.1	<0.005	<0.1	<0.5	<0.5	0.14	0.01
EB-90M	06Ely04B FA	0.77	2.6	1.2	19.3	2.39	113	63.1	0.1	0.31	<0.2	2	0.1	0.081	0.46	<0.5	0.82	5.8	0.48
EB-90M	06Ely04B RA	<0.3	2.3	1	18.8	2.4	110	63.8	0.06	0.32	<0.2	4	<0.1	0.078	0.52	<0.5	<0.5	5.85	0.48
EB-90M	06Ely04C FA	<0.3	4.2	2.6	22.1	4.58	234	82	<0.02	0.6	<0.2	3.8	0.1	0.15	0.69	<0.5	<0.5	13.4	0.97
EB-90M	06Ely04D FA	<0.3	6.4	2.9	36	6.03	407	113	<0.02	0.73	0.21	5.7	0.2	0.17	1.01	<0.5	<0.5	15.9	1.11
SB-3670M	06Ely05B FA	<0.3	0.7	<1	6.2	<0.01	7	191	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.26	<0.5	<0.5	0.02	<0.005
SB-3670M	06Ely05B RA	<0.3	0.7	<1	6.4	<0.01	7	194	<0.02	<0.005	<0.2	1.6	<0.1	<0.005	0.26	<0.5	<0.5	0.04	<0.005
SB-3670M	06Ely05C FA	<0.3	1.3	<1	8.5	0.02	16	274	<0.02	<0.005	<0.2	4.1	<0.1	<0.005	0.42	0.6	<0.5	0.09	0.009
SB-3670M	06Ely05D FA	0.88	1.7	<1	11.1	0.01	18	457	<0.02	<0.005	<0.2	0.5	0.2	<0.005	1.07	1	0.56	0.09	0.007
SB-2400M	06Ely06B FA	0.53	1	<1	9.1	<0.01	21	209	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.33	<0.5	<0.5	0.03	<0.005
SB-2400M	06Ely06B RA	<0.3	0.9	<1	9.1	0.01	20	211	<0.02	<0.005	<0.2	1.2	<0.1	<0.005	0.33	<0.5	<0.5	0.04	<0.005
SB-2400M	06Ely06C FA	0.33	1.5	1.2	10.1	0.02	43	285	<0.02	<0.005	<0.2	12	<0.1	<0.005	0.54	<0.5	<0.5	0.09	0.01
SB-2400M	06Ely06D FA	0.3	1.8	1.5	13.1	<0.01	101	430	<0.02	<0.005	<0.2	3.1	0.1	<0.005	0.72	<0.5	<0.5	0.08	<0.005
SB-1360M	06Ely07B FA	<0.3	0.7	<1	7.2	<0.01	14	159	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.23	<0.5	<0.5	0.02	<0.005
SB-1360M	06Ely07B RA	<0.3	0.8	<1	7.2	0.01	14	160	<0.02	<0.005	<0.2	3.1	<0.1	<0.005	0.22	<0.5	<0.5	0.06	0.006
SB-1360M	06Ely07C FA	0.44	1.2	1.3	8.3	0.02	34	224	<0.02	<0.005	<0.2	2.9	<0.1	<0.005	0.37	<0.5	<0.5	0.07	0.008
SB-1360M	06Ely07D FA	<0.3	1.6	1.1	11.9	<0.01	83	436	<0.02	<0.005	<0.2	1.1	<0.1	<0.005	0.62	<0.5	<0.5	0.06	<0.005
SB-140M	06Ely08B FA	<0.3	0.7	<1	7	<0.01	15	168	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.2	<0.5	<0.5	0.02	<0.005
SB-140M	06Ely08B RA	<0.3	0.8	<1	7.2	<0.01	15	176	<0.02	<0.005	<0.2	0.7	<0.1	<0.005	0.2	<0.5	<0.5	0.02	<0.005
SB-140M	06Ely08C FA	<0.3	1	<1	7	<0.01	20	272	<0.02	<0.005	<0.2	0.8	<0.1	<0.005	0.4	<0.5	<0.5	0.04	0.005
SB-140M	06Ely08D FA	<0.3	1.5	1	11.1	<0.01	61	397	<0.02	<0.005	<0.2	0.8	<0.1	<0.005	0.62	<0.5	<0.5	0.06	0.006
OR-24050M	06Ely09B FA	<0.3	0.9	<1	8.7	<0.01	8	228	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.4	<0.5	<0.5	0.02	<0.005
OR-24050M	06Ely09B RA	<0.3	0.9	<1	9.1	<0.01	9	224	<0.02	<0.005	<0.2	1.3	<0.1	<0.005	0.4	<0.5	<0.5	0.03	<0.005
OR-24050M	06Ely09C FA	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins	ins
OR-24050M	06Ely09D FA	<0.3	2.2	1.2	14.5	0.01	11	559	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	1.91	1.8	<0.5	0.16	0.009
OR-23200M	06Ely10B FA	<0.3	0.7	<1	7.1	<0.01	12	150	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.32	<0.5	<0.5	0.02	<0.005
OR-23200M	06Ely10B RA	<0.3	0.8	<1	7.4	0.01	12	152	<0.02	<0.005	<0.2	2.3	<0.1	<0.005	0.34	<0.5	<0.5	0.04	0.005
OR-23200M	06Ely10C FA	<0.3	1	<1	6.3	0.01	19	282	<0.02	<0.005	<0.2	0.9	<0.1	<0.005	0.7	1	<0.5	0.07	0.007
OR-23200M	06Ely10D FA	<0.3	1.7	<1	12.2	0.01	27	386	<0.02	<0.005	<0.2	<0.5	<0.1	<0.005	0.95	<0.5	<0.5	0.06	0.006

Appendix 7. Constituents in pore waters collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[S.C., specific conductance; DOC, dissolved organic carbon; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cfs, cubic feet per second; L/s, liters per second; µg/L, micrograms per liter; ng/L, nanograms per liter; ICP-AES, inductively coupled plasma-atomic emission spectroscopy; ICP-MS, inductively coupled plasma-mass spectrometry; IC, ion chromatography; CVAF, cold-vapor atomic fluorescence; —, not determined; <, analyte not detected at the reporting level; ins, insufficient sample]

Site No.	Previous sample ID	Zn (µg/L) ICP-MS	Zr (µg/L) ICP-MS	Job No. IC	Lab No. IC	Field No. IC	Cl (mg/L) IC	F (mg/L) IC	NO_3 (mg/L) IC	SO_4 (mg/L) IC	Job No. CVAF	Lab No. CVAF	Field No. CVAF	Hg (ng/L) CVAF
EB-1080M	06Ely01B FA	1.5	<0.2	MRP-07540	C-289415	06Ely01B FU	1.4	<.08	0.5	4.4	MRP-07542	C-289491	06Ely01B Hg	<5
EB-1080M	06Ely01B RA	1.7	<0.2	—	—	—	—	—	—	—	—	—	—	—
EB-1080M	06Ely01C FA	29.2	<0.2	—	—	—	—	—	—	—	—	—	—	—
EB-1080M	06Ely01D FA	1.6	<0.2	MRP-07597	C-290573	06Ely01D FU	3.2	0.2	2.7	14	—	—	—	—
EB-770M	06Ely02B FA	25.1	<0.2	MRP-07540	C-289417	06Ely02B FU	1.4	0.09	<.08	43	MRP-07542	C-289493	06Ely02B Hg	<5
EB-770M	06Ely02B RA	21.9	<0.2	—	—	—	—	—	—	—	—	—	—	—
EB-770M	06Ely02C FA	50	<0.2	—	—	—	—	—	—	—	—	—	—	—
EB-770M	06Ely02D FA	114	<0.2	MRP-07597	C-290574	06Ely02D FU	2.8	0.2	1.4	175	—	—	—	—
EB-600M	06Ely03B FA	31.6	<0.2	MRP-07540	C-289419	06Ely03B FU	1.4	0.1	0.5	35	MRP-07542	C-289495	06Ely03B Hg	<5
EB-600M	06Ely03B RA	26.4	<0.2	—	—	—	—	—	—	—	—	—	—	—
EB-600M	06Ely03C FA	24.8	<0.2	—	—	—	—	—	—	—	—	—	—	—
EB-600M	06Ely03D FA	26	<0.2	MRP-07597	C-290575	06Ely03D FU	1.5	0.1	0.7	47	—	—	—	—
EB-90M	06Ely04B FA	314	<0.2	MRP-07540	C-289421	06Ely04B FU	3.4	0.6	<.08	161	MRP-07542	C-289497	06Ely04B Hg	<5
EB-90M	06Ely04B RA	317	<0.2	—	—	—	—	—	—	—	—	—	—	—
EB-90M	06Ely04C FA	514	<0.2	—	—	—	—	—	—	—	—	—	—	—
EB-90M	06Ely04D FA	616	0.2	MRP-07597	C-290576	06Ely04D FU	7	0.5	<.08	574	—	—	—	—
SB-3670M	06Ely05B FA	1.9	<0.2	MRP-07540	C-289424	06Ely05B FU	3.5	<.08	<.08	6	MRP-07542	C-289500	06Ely05B Hg	<5
SB-3670M	06Ely05B RA	0.7	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-3670M	06Ely05C FA	3.8	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-3670M	06Ely05D FA	4.4	<0.2	MRP-07597	C-290577	06Ely05D FU	7	<.08	1.8	16	—	—	—	—
SB-2400M	06Ely06B FA	3	<0.2	MRP-07540	C-289429	06Ely06B FU	—	<.08	—	—	MRP-07542	C-289505	06Ely06B Hg	<5
SB-2400M	06Ely06B RA	6.4	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-2400M	06Ely06C FA	6.4	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-2400M	06Ely06D FA	4.9	<0.2	MRP-07597	C-290578	06Ely06D FU	14	<.08	2.5	99	—	—	—	—
SB-1360M	06Ely07B FA	149	<0.2	MRP-07540	C-289432	06Ely07B FU	4	<.08	0.9	17	MRP-07542	C-289508	06Ely07B Hg	<5
SB-1360M	06Ely07B RA	2.6	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-1360M	06Ely07C FA	6	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-1360M	06Ely07D FA	7	<0.2	MRP-07597	C-290579	06Ely07D FU	6.1	<.08	2.3	87	—	—	—	—
SB-140M	06Ely08B FA	8	<0.2	MRP-07540	C-289434	06Ely08B FU	7.1	<.08	1	16	MRP-07542	C-289510	06Ely08B Hg	<5
SB-140M	06Ely08B RA	3.1	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-140M	06Ely08C FA	5.3	<0.2	—	—	—	—	—	—	—	—	—	—	—
SB-140M	06Ely08D FA	7.4	<0.2	MRP-07597	C-290580	06Ely08D FU	7	<.08	2.5	64	—	—	—	—
OR-24050M	06Ely09B FA	3.8	<0.2	MRP-07540	C-289436	06Ely09B FU	15	<.08	4.5	10	MRP-07542	C-289512	06Ely09B Hg	<5
OR-24050M	06Ely09B RA	1.4	<0.2	—	—	—	—	—	—	—	—	—	—	—
OR-24050M	06Ely09C FA	ins	ins	—	—	—	—	—	—	—	—	—	—	—
OR-24050M	06Ely09D FA	2.4	<0.2	MRP-07597	C-290582	06Ely09D FU	15	<.08	2	11	—	—	—	—
OR-23200M	06Ely10B FA	2.9	<0.2	MRP-07540	C-289439	06Ely10B FU	15	0.1	0.5	11	MRP-07542	C-289515	06Ely10B Hg	<5
OR-23200M	06Ely10B RA	1.4	<0.2	—	—	—	—	—	—	—	—	—	—	—
OR-23200M	06Ely10C FA	3.4	<0.2	—	—	—	—	—	—	—	—	—	—	—
OR-23200M	06Ely10D FA	5.7	<0.2	MRP-07597	C-290583	06Ely10D FU	12	<.08	3	25	—	—	—	—

[1] Estimated value, reported concentration is less than the reporting level but greater than the long-term method-detection level (E).

Appendix 8. Chemistry results for sediments collected in August and September 2006 from the Ely Mine study area, Vershire, VT.

[wt. %, weight percent; mg/kg, milligrams per kilogram; —, not determined; <, analyte not detected at the reporting level]

Site number	Field number	Date	Job number	Lab number	Total C (wt. % as C)	CO_2 (wt. % as C)	Carbonate (wt. % as C)	Total organic C (wt. % as C)	Hg (mg/kg)	Al (wt. %)	Ca (wt. %)	Fe (wt. %)	K (wt. %)	Mg (wt. %)
PEC[a]		—	—	—	—	—	—	—	1.06	—	—	—	—	—
EB-1080M	06Ely01	8/23/2006	MRP-07598	C-290586	0.35	0.04	0.01	0.34	<0.02	4.26	1.05	2.76	1.03	0.98
EB-770M	06Ely02	8/23/2006	MRP-07598	C-290587	0.55	0.07	0.02	0.53	<0.02	4.81	1.24	5.5	1.06	1.01
EB-600M	06Ely03	8/23/2006	MRP-07598	C-290589	0.25	0.09	0.02	0.23	<0.02	4.66	1.25	7.09	1.05	1.05
EB-90M	06Ely04	8/23/2006	MRP-07598	C-290590	0.28	0.06	0.02	0.26	<0.02	3.98	1.13	16.7	0.95	0.76
EB-90M (overbank sed.)	06Ely04-OBS	8/23/2006	MRP-07598	C-290592	2.46	0.15	0.04	2.42	0.13	3.21	0.31	36.3	2.45	0.7
SB-3670M	06Ely05	8/22/2006	MRP-07598	C-290593	0.52	0.75	0.2	0.32	<0.02	3.1	1.42	1.39	0.81	0.66
SB-2400M	06Ely06	8/22/2006	MRP-07598	C-290594	0.41	0.69	0.19	0.22	<0.02	3.61	1.34	2.03	0.86	0.63
SB-1360M	06Ely07	8/23/2006	MRP-07598	C-290595	0.4	0.56	0.15	0.25	<0.02	3.48	1.62	2.78	0.85	0.67
SB-140M	06Ely08	8/22/2006	MRP-07598	C-290596	0.34	0.35	0.1	0.24	<0.02	3.69	1.3	2.63	0.92	0.62
OR-24050M	06Ely09	8/22/2006	MRP-07598	C-290598	0.41	0.15	0.04	0.37	<0.02	3.27	1.13	1.4	0.8	0.73
OR-23200M	06Ely10	8/22/2006	MRP-07598	C-290599	0.3	0.17	0.05	0.25	<0.02	3.54	1.3	2.28	0.84	0.71
EB-20M	06Ely11	8/23/2006	MRP-07598	C-290600	0.55	0.08	0.02	0.53	0.03	4.12	1.08	14.6	1.03	0.73
SB-3260M	06Ely12	8/23/2006	MRP-07598	C-290601	0.39	0.48	0.13	0.26	<0.02	3.56	1.43	5.88	0.82	0.62
EM-POND1	06ElyPond1S	09/19/06	MRP-07598	C-290602	8.04	0.16	0.04	8	0.07	6.68	1.93	4.39	0.89	1.56
EM-POND2	06ElyPond2S	09/19/06	MRP-07598	C-290603	9.36	0.23	0.06	9.3	0.11	6.12	1.89	4.48	1.09	1.38
EM-POND3	06ElyPond3S	09/19/06	MRP-07598	C-290604	10.4	0.26	0.07	10.33	0.15	5.49	1.47	5.84	0.84	1.22
EM-POND4	06ElyPond4S	09/19/06	MRP-07598	C-290605	10.1	0.18	0.05	10.05	0.09	5.63	1.11	3.88	1.11	1.25
EM-POND5	06ElyPond5S	09/19/06	MRP-07598	C-290606	9.57	0.26	0.07	9.5	0.09	6.45	0.92	4.99	0.79	1.02
EM-POND6	06ElyPond6S	09/19/06	MRP-07598	C-290607	6.54	0.27	0.07	6.47	0.07	11.1	0.67	3.5	0.75	0.73

Appendix 8. Chemistry results for sediments collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[wt. %, weight percent; mg/kg, milligrams per kilogram; —, not determined; <, analyte not detected at the reporting level]

Site number	Na (wt. %)	S (wt. %)	Ti (wt. %)	Ag (mg/kg)	As (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Bi (mg/kg)	Cd (mg/kg)	Ce (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cs (mg/kg)	Cu (mg/kg)	Ga (mg/kg)	In (mg/kg)	La (mg/kg)	Li (mg/kg)	Mn (mg/kg)
PEC[a]	—	—	—	—	33	—	—	—	4.98	—	—	111	—	149	—	—	—	—	—
EB-1080M	1	0.04	0.29	<1	<1	249	1.4	0.19	0.1	23.3	9.8	57	<5	75.4	10.5	0.04	13.5	24	780
EB-770M	1.06	0.3	0.36	<1	2	255	1.6	0.31	0.4	33	22.4	66	<5	1,160	11.5	0.08	17.3	22	2,090
EB-600M	1.05	0.41	0.32	<1	3	236	1.5	0.5	1	41.1	65.5	64	<5	2,730	11.4	0.1	19.4	21	1,820
EB-90M	1.06	1.7	0.32	3	2	166	1.1	1.61	1	11.4	14.4	62	<5	5,950	10.4	0.26	6	10	2,200
EB-90M (overbank sed.)	0.56	4.66	0.34	17	4	360	0.7	7.41	0.2	23.5	13.3	89	5	1,440	16.1	0.42	13	16	429
SB-3670M	0.68	0.03	0.14	<1	3	207	1.8	0.13	<0.1	19.5	4.8	24	<5	10.4	7.99	0.02	10.5	24	501
SB-2400M	0.76	0.08	0.14	<1	1	191	1.7	0.21	0.1	19.8	10.8	23	<5	167	8.2	0.04	10.6	22	504
SB-1360M	0.79	0.1	0.21	<1	1	191	1.6	0.18	0.2	19	9.6	28	<5	198	7.68	0.03	10	24	864
SB-140M	0.79	0.08	0.22	<1	1	198	1.6	0.18	0.2	24.1	13.5	32	<5	243	8.49	0.03	11.7	19	869
OR-24050M	0.72	0.02	0.16	<1	3	187	1.6	0.09	<0.1	16.5	4.5	37	<5	4.5	7.68	<0.02	9.3	28	475
OR-23200M	0.76	0.03	0.27	<1	5	195	1.8	0.07	0.1	21.7	8.1	29	<5	76.7	7.77	0.03	10.9	24	1,120
EB-20M	1.19	1.41	0.27	3	2	191	1.3	1.74	0.7	14.1	15.1	67	<5	3,700	11.8	0.22	7.4	13	1,020
SB-3260M	0.8	0.42	0.23	<1	2	173	1.4	0.56	0.3	19.6	11	40	<5	1,390	8.54	0.08	9.9	18	1,120
EM-POND1	1.78	0.42	0.51	<1	<1	276	1.8	0.3	0.8	45.1	19.8	102	6	86.6	17.4	0.08	27.9	44	527
EM-POND2	1.3	0.54	0.52	<1	<1	321	1.8	0.31	1.3	56.7	24	130	5	87.6	15.7	0.07	30.4	44	769
EM-POND3	0.91	0.37	0.46	<1	3	377	1.6	0.3	1.2	68.6	30.9	85	5	81.7	13.9	0.06	34.2	39	3,130
EM-POND4	0.69	0.34	0.31	<1	7	337	1.6	0.18	2.5	65.2	29.2	67	5	380	13.6	0.05	28.4	41	2,410
EM-POND5	0.89	0.71	0.3	<1	3	296	1.6	0.17	4	102	78.3	70	<5	3,540	11.3	0.05	49.4	32	1,430
EM-POND6	0.65	0.93	0.19	<1	3	184	2.2	0.26	0.2	70.1	13.3	47	<5	1,770	10.7	0.06	23.1	23	443

Appendix 8. Chemistry results for sediments collected in August and September 2006 from the Ely Mine study area, Vershire, VT.—Continued

[wt. %, weight percent; mg/kg, milligrams per kilogram; —, not determined; <, analyte not detected at the reporting level]

Site No.	Mo (mg/kg)	Nb (mg/kg)	Ni (mg/kg)	P (mg/kg)	Pb (mg/kg)	Rb (mg/kg)	Sb (mg/kg)	Sc (mg/kg)	Sn (mg/kg)	Sr (mg/kg)	Te (mg/kg)	Th (mg/kg)	Tl (mg/kg)	U (mg/kg)	V (mg/kg)	W (mg/kg)	Y (mg/kg)	Zn (mg/kg)	Se (mg/kg)
PEC[a]	—	—	48.6	—	128	—	—	—	—	—	—	—	—	—	—	—	—	459	—
EB-1080M	0.41	3.9	16.5	330	24.8	49.9	<0.05	10	1.5	133	<0.1	3.8	0.3	0.9	73	0.4	11.1	56	0.3
EB-770M	2.11	5.1	20	390	14.6	50.5	0.06	16	1.4	111	0.2	4.5	0.3	1.4	96	0.5	20.7	122	4.1
EB-600M	8.33	4.5	23.4	280	174	47.5	1.15	15.2	1.8	99	0.3	4.5	0.3	1.6	97	0.6	18.4	186	8.1
EB-90M	17.4	3.6	10.6	120	38.1	36	2.03	13	2.6	73.1	1	2.5	0.3	0.7	112	0.6	12.5	206	30.1
EB-90M (overbank sed.)	44.5	7.2	19.9	790	78.6	106	0.53	10.6	3.4	55.3	2.7	5.4	1.3	0.9	154	1.1	5	147	71.1
SB-3670M	0.28	3.8	13.2	260	11.2	44.3	0.15	5.6	1.1	202	<0.1	3.5	0.2	0.8	40	0.4	8.5	32	<0.2
SB-2400M	2.29	4.8	11.4	260	10.5	43.8	0.65	8.6	1	193	<0.1	3.6	0.2	0.8	43	0.4	12.4	54	1.8
SB-1360M	2.53	3.3	11.6	290	11	43.1	1.8	6.6	1.2	206	<0.1	3.4	0.2	0.8	48	0.5	7.8	66	1.5
SB-140M	2.59	5.1	13.6	260	31.4	45	2.14	9.3	2.2	188	<0.1	3.6	0.2	0.9	52	0.5	10.8	85	1.1
OR-24050M	0.16	4	11.7	260	9.6	42	0.19	5.6	1.1	198	<0.1	2.8	0.2	0.7	38	0.3	8.1	33	<0.2
OR-23200M	0.5	5.3	10.8	270	10.4	40.5	0.22	8.6	1.7	193	<0.1	3.5	0.2	0.8	49	0.4	14	53	0.3
EB-20M	16.2	4.2	15	270	38	40.7	1.15	11.6	2.3	92.2	1.1	2.8	0.3	0.8	112	0.7	7.9	196	35.2
SB-3260M	7.26	4.7	11.5	230	17.9	37.7	2.39	10.5	2.2	164	0.3	3.3	0.2	1	62	0.6	12.8	93	9.8
EM-POND1	0.63	10.9	35.6	980	26.4	54.8	<0.05	17.5	3	172	<0.1	5.2	0.4	2.3	163	0.7	28.8	126	0.7
EM-POND2	2.58	10.3	45.4	1,020	31.8	54.2	0.11	15.8	2.7	165	<0.1	6.4	0.6	3.5	148	0.8	26.8	131	1.1
EM-POND3	2.15	9.3	38.6	1,120	43.7	44.4	0.3	14.4	2.5	134	<0.1	7.7	0.8	3.5	125	0.8	27.5	127	1.4
EM-POND4	1.75	5.2	61.1	660	20.2	52.7	0.31	12	1.9	91.9	<0.1	8	0.5	3.1	93	0.7	22.5	316	0.7
EM-POND5	2.54	6	56.8	610	23.5	34.8	0.97	12.7	1.6	76.5	<0.1	6.4	0.5	5.7	79	0.6	32.1	507	1.3
EM-POND6	2.8	5	29.5	550	18.4	32.3	1.42	13.1	1.4	94.2	<0.1	5.3	0.2	6.2	68	0.6	27.9	68	1.4

[a] Probable effect concentration (MacDonald and others, 2000).

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